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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) REPORT

406 MHZ DELTA STUDY:

ADVANTAGES OF 406 MHZ EMERGENCY LOCATOR TRANSMITTERS (ELTS) OVER 121.5/243 MHZ ELTS

JULY 1996

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Direct Services Division
Washington, DC 20233

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DOCUMENT APPROVAL PAGE

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LIST OF ACRONYMS

AFRCC	Air Force Rescue Coordination Center
CAP	Civil Air Patrol
COSPAS	Space System for the Search of Vessels in Distress
D&E	Demonstration and Evaluation
DoD	Department of Defense
DOT	Department of Transportation
EPIRB	Emergency Position Indicating Radio Beacon
ELT	Emergency Locator Transmitter
FAA	Federal Aviation Administration
GEOSAR	Geostationary Search and Rescue
GPS	Global Positioning System
ID	Identification
ITU	International Telecommunications Union
LEO	Low Earth Orbit
LKP	Last Known Position
LUT	Local User Terminal
MCC	Mission Control Center
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NTSB	National Transportation Safety Board
RCC	Rescue Coordination Center
RF	Radio Frequency
RTCA	Requirements and Technical Concepts for Aviation
SALTTI	Study of Alerting and Locating Techniques and Their Impact
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite-Aided Tracking
TSO	Technical Standard Order
USAF	United States Air Force
USCG	United States Coast Guard
USMCC	United States Mission Control Center

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1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE

This study compares the benefits using a 406 MHz ELT over those of a 121.5 MHz ELT. The benefits are quantified in terms of dollars and lives saved.

1.2 BACKGROUND

A National Aeronautics and Space Administration (NASA) study[1] examined the causes of 121.5 MHz ELT[2] failures based on a review of National Transportation Safety Board (NTSB) data. Data from accidents for calendar years 1983 through 1987 were analyzed. Of the 12,744 accident reports during this period, 3,270 contained information concerning the ELT. In the accidents where ELT data was available, the ELT failed to operate 75% of the time. The causes for these failures were available in 1,319 cases. These causes were then analyzed by a group of experts to estimate the reduction in failures that could be expected from an improved 121.5 MHz ELT[3]. This resulted in an expected crash survival rate of 73% for the improved 121.5 MHz ELT.

The 406 MHz Delta Study follows the same approach to estimate the additional reduction in failures to be expected from the use of 406 MHz ELT[4].

1.3 SYSTEM OVERVIEW

The Cospas-Sarsat system receives and processes signals in three frequency bands: 121.5 MHz, 243.0 MHz[5], and 406 MHz. Because the Cospas-Sarsat satellites are in low earth orbit they are not always in view of the distress site. Each satellite makes a pass over a given area from 4 to 6 times a day. On the average there is a satellite pass every 1.5 to 2 hours with the normal constellation of 4 satellites. For 121.5 and 243.0 MHz data, the Doppler-shifted frequency is placed on the satellite downlink and transmitted back to earth in real time (no processing is done on the satellite) where it

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[1] NASA Contractor Report 4330 entitled "Current Emergency Locator Transmitter (ELT) Deficiencies and Potential Improvements Utilizing TSO-C91a ELTs," October 1990.
[2] ELTs built to TSO-C91 specifications.
[3] ELTs built to TSO-C91a (RTCA-DO-183) specifications.
[4] ELTs built to TSO-C126 (RTCA-DO-204) specifications.
[5] Cospas satellites do not receive the 243 MHz frequency.

is received and processed when a ground station (Local User Terminal) is in view. For 406 MHz transmissions, spacecraft equipment measures the Doppler-shifted frequency and detects the ELT digital data message. The data is time tagged and stored in the spacecraft as well as being transmitted in real time to ground stations that may be in view. Thus, real-time 121.5 /243.0 MHz data and 406 MHz data may be received by a ground station within view of the satellite; however, only the 406 MHz system provides full earth coverage (i.e., when the satellite is not in view of a ground station). The processed alerts are forwarded to a Mission Control Center (MCC) where they are distributed to the appropriate Rescue Coordination Center (RCC) according to the location determined by Doppler.

With the recent launch of Geostationary Search and Rescue (GEOSAR) satellites carrying 406 MHz repeaters, the signals from 406 MHz ELTs are received in real time, processed by the GEOSAR ground stations and forwarded to the search and rescue MCC. Since no Doppler is available from the GEOSAR satellites, a registration data base is used to route the GEOSAR alerts. Based upon the location of the point of registry, the GEOSAR alert is forwarded to the appropriate RCC, where calls to the emergency point of contact are made to determine the most probable area of the distress.

In the future, location information is expected to be added to the GEOSAR 406 MHz alert message by the use of GPS or other sources of location information. This location information will then be used to route the alert to the appropriate RCC, allowing immediate action by the RCC.

2.0 ADVANTAGES OF THE 406 MHZ SYSTEM

The advantages of the 406 MHz System will be examined from two perspectives: the advantages of the 406 MHz ELT (Section 2.1) and the advantages of the 406 MHz satellite system (Section 2.2).

2.1 ADVANTAGES OF THE 406 MHZ ELT

The advantages of the 406 MHz ELT are:

- Improved Survivability (including fire protection)
- A Built-in Self Test Requirement
- Both Aural and Visual Monitors

2.1.1 Improved Survivability

Examination of Table 7, Page 12 from the NASA ELT Study reveals that a large number of ELT failures will still occur even when using the improved 121.5 MHz ELT. Specifically the failures due to fire, impact damage, and internal failures account for 345 of the expected 481 failures.

The specific survivability advantages of the 406 MHz ELTs (over and above the requirements in the TSO-C91a) are:

- Requirement for Fire Survival Tests (TSO-C91a has none)
- Additional Shock Tests While the ELT is Operating
- Operation of the ELT During the Protrusion and Pressure Survival Tests
- More Stringent Temperature Soak Test
- Additional Thermal Shock Endurance Test
- Decompression Requirement Simulating Actual Operating Conditions
- Requirement to Ensure Waterproof Enclosure After Replacing Battery

2.1.2 A Built-in Self Test Requirement

The 406 MHz ELT has a built-in self-test feature. This feature alerts the pilot that maintenance, such as battery replacement, is required. This feature will accrue the preventive maintenance advantages that are indicated in Table 7 of the NASA study.

2.1.3 Both Aural and Visual Monitors

The improved 121.5 MHz ELT requires either an aural or visual monitor in the cockpit to alert the pilot that the ELT transmitter has been activated. Generally, the visual monitor is employed as a standard feature. The 406 MHz specification requires both aural and visual monitors. The audio monitor would complement the visual monitor and insure early detection of the ELT, especially when no one is in the plane and ground personnel need to find the location of an inadvertent ELT activation. Early discovery by the pilot or airport ground personnel of an inadvertent ELT activation will help terminate false alarms sooner and possibly eliminate some of the dead battery problems.

2.2 SYSTEM ADVANTAGES

The 406 MHz ELT has a number of significant system advantages over the improved 121.5 MHz[6] ELTs. These advantages are:

- Identification Contained Within the Message
- No False Alerts [7]
- Greater Accuracy of Location
- High Probability of Ambiguity Resolution on First Satellite Pass

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[6] For convenience purposes in this report, the term "121.5 MHz ELT" will also include the 243 MHz frequency.
[7] A "false alert" is a distress alert notification generated by the Cospas-Sarsat system from other than distress transmitters. They are generated by other RF signals in the band or from noise.

- Higher Power Transmitter
- Capability of Detection from GEOSAR Satellites
- Global Coverage
- Greatly Increased System Capacity
- 406 MHz Band Allocated for Satellite-Aided Search & Rescue

2.2.1 Identification Contained Within the Message

One of the main advantages of the 406 MHz system is the digital data message. The digital message contained in the 406 MHz beacon transmission can provide RCCs with identification data, nationality, type of user, and various other options such as type of emergency, etc. Among the many improvements in rescue operations that result from positive identification, the following are significant to both improving rescue response and reducing SAR forces' workload:

1. When the beacon is registered in a data base,[8] the RCC is able to immediately start a communications cross-check with the owner and/or home airport to determine if an emergency exists. False alarms[9] can be dealt with quickly and in many cases this will avert the launching of SAR forces. In real distress situations this will enable earlier launching of the SAR forces.

2. Multiple distress messages in the same area can be dealt with more effectively than 121.5 MHz messages where there is no precise way of segregating one case from another.

3. The digitally encoded message allows the detection of 406 MHz ELT/ Emergency Position Indicating Radio Beacon (EPIRB) signals from GEOSAR satellites which provide nearly immediate notification to the RCC when a beacon is activated.

2.2.2 No False Alerts

The satellite system will look for the required signal format before it will process a 406 MHz transmission. This provides the ability to determine that the signal is coming from an ELT or EPIRB and not from an interfering source. Hundreds of 121.5 MHz incident locations received by the Cospas-Sarsat satellite system are generated by radio frequency (RF) radiation from sources other than ELTs or EPIRBs. For instance, there have even been cases where pizza vending machines have generated 121.5 MHz alerts which resulted in the needless launching of SAR missions.

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[8]FCC regulations require registration of all 406 MHz emergency beacons.

[9] False alarms are signals from non-distress situations which are radiated by a distress transmitter. A "false alarm" occurs when an actual ELT or EPIRB is transmitting in a non-distress situation.

2.2.3 Greater Accuracy of Location

The improved oscillator stability of the 406 MHz ELT results in a significant improvement in accuracy. Results of controlled engineering tests during the Cospas-Sarsat Demonstration and Evaluation Phase (D&E)[10] demonstrated that 406 MHz had a ten-fold improvement in accuracy when compared to the 121.5 MHz location results (85% less than 2 Km vs. 68% less than 20 Km). Therefore, the area to be searched is 13 square kilometers vs. 1300 square kilometers.

2.2.4 High Probability of Ambiguity Resolution on First Satellite Pass

The improved oscillator stability of the 406 MHz ELT also allows resolving the ambiguity of location on the first satellite pass with a high probability of success. Data taken during the D&E showed that the ambiguity of 406 MHz signals were resolved more than 95% of the time. This factor alone will save on the order of two hours in the rescue timeline since 121.5 MHz transmissions must wait for a second pass to resolve the ambiguity of location.

2.2.5 Higher Power Transmitter

With an output power of five watts (vs. 75 milliwatts for the 121.5 MHz ELTs) the 406 MHz ELTs provide a greater reception margin to the Cospas-Sarsat low orbiting satellites which, under some crash conditions, could mean the difference between detection and non-detection of the distress signal. The higher power also allows detection by GEOSAR satellites which significantly shortens the rescue response time.

2.2.6 Capability of Detection by GEOSAR Satellites

Because of its higher power, the 406 MHz ELT can be detected by GEOSAR satellites. (The 121.5 MHz ELTs can only be detected by the low orbit Cospas-Sarsat satellites.) A GEOSAR operational capability is already in place in a number of countries and a global system should be available within a few years. In the U.S. the GOES satellite service is in operation with a 406 MHz repeater and will continue to have the 406 MHz capability into the foreseeable future. With location data added to the digital message[11] and/or with the data contained in the MCC data base, the RCC can begin immediate actions to validate the emergency and launch rescue forces.

2.2.7 Global Coverage

The digitally encoded format of the 406 MHz ELT allows processing and storage of the messages on-board the satellite, which provides for complete global coverage. Thus, a plane carrying a 406 MHz ELT will have the ability to be detected and located anywhere on the earth. This is not true in

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[10] Cospas-Sarsat Project Report, August 1984, page 4-4 through 4-7.

[11]. A location protocol message will allow the insertion of location in the distress message using a GPS receiver or other source of in-situ location.

the case of the 121.5 MHz signals which are only relayed through the satellite, requiring a Local User Terminal (LUT) to be in view of the satellite to receive the distress message.

2.2.8 Greatly Increased System Capacity

The 406 MHz ELT transmits a burst message of approximately 1/2 second every 50 seconds. Through a combination of frequency spreading and random time sharing of the spectrum, the capacity of the 406 MHz satellite system can accommodate hundreds of distress signals within the field of view of the satellite. The continuous transmission mode of the 121.5 MHz ELTs limits the capacity of that system to current usage, thus not allowing for any substantial growth in the number of users.

2.2.9 406 MHz Band Allocated for Satellite-Aided Search and Rescue

The 406 MHz ELT was specifically designed to take advantage of the satellite detection system. The use of the band from 406.0 to 406.1 MHz has been assigned by the International Telecommunications Union (ITU) Radio Regulations, Nos. 649 and 2998A. These regulations limit the band to low-power, satellite emergency locator transmitters/beacons. Although there is currently some interference in the 406 MHz band, these interfering transmitters do not produce locations at the RCCs as in the case of 121.5 MHz interferers because of the ID feature in the distress messages. Once existing sources of interference are eliminated, the band should be almost free from interference in the future. In the 121.5 MHz frequency band, transmitters of much higher power are allowed which can suppress the lower power ELT signals.

3.0 OPERATIONAL ADVANTAGES OF THE 406 MHZ SYSTEM

A fully successful search and rescue operation can be viewed as one in which everyone that survives the distress is recovered alive in the least amount of time. The percentage of survivors who continue to survive after an aircraft accident decreases with the passage of time. According to a Department of Transportation (DOT) paper,[12] less than 60% of the initial survivors would still be alive when recovered eight hours after the distress. The number of survivors still alive drops to less than 10% when recovered two days after the distress. After five days, the number of survivors approaches zero. The sooner rescue personnel reach a distress site, the more likely it is that they will find and recover survivors.

The 406 MHz ELT has definite advantages when used with the Cospas-Sarsat system which can provide significant reductions in the time between accident occurrence and arrival of the rescue forces at the distress site.

A typical SAR operation normally progresses through five stages: notification, evaluation, transit, search, and recovery. The notification stage begins with the aircraft crash and ends when either the

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[12] DoD and NSC data given in C. Mundo, L. Tami & G. Larson, Final Report Program Plan for Search and Rescue Electronics Alerting and Locating System, DOT-TSC-73-42, February 1974.

RCC is notified of the crash or when the aircraft is reported overdue. The planning/evaluation stage begins when the RCC is notified and ends when a mission is opened and rescue forces are dispatched to the search area. The transit stage begins when the resources depart for the search and ends when the resources arrive in the search area. The search stage begins when the resources arrive in the search area and ends when the crash site and/or survivors are located or when the search is terminated. The recovery stage begins when rescue forces have located the survivors and ends when the survivors are en route to a medical facility.

The three stages which can be influenced by the Cospas-Sarsat system are: notification, planning/evaluation, and search. The following discussion, therefore, is limited to these three stages.

3.1 NOTIFICATION STAGE

Before a SAR operation is initiated, there must be some notification of a distress situation. In the aviation community, notification of a possible distress is generally received by a declared emergency when the aircraft fails to land at its destination or when the Cospas-Sarsat satellite system detects and locates the aircraft's ELT signal. Depending on the type of flight plan (or lack of one) and destination airfield, hours can elapse between the time the aircraft crashes and when the aircraft is reported overdue. Since there is no data available for the time between actual crash and Air Force Rescue Coordination Center (AFRCC) notification, the best indication of elapsed time is the time from last known position (LKP) to AFRCC notification. Table 1 shows the average time lapse for 121.5 MHz ELTs from the LKP of the aircraft to when the RCC was notified of a possible distress. Even when the aircraft had a working ELT, there was an average delay in excess of four hours between the time of the last known position and when the AFRCC was notified.

TABLE 1. AFRCC Aircraft Missions

Average Time (Hours) from LKP to RCC Notification*

Year	ELT Worked [13]	ELT Did Not Work
1984	8.72	13.25
1985	4.67	20.21
1986	5.15	14.21
1987	4.30	6.20
1988	0.53	14.31
1989	5.00	7.90
Average**	5.57	12.34

* Source: AFRCC Annual Reports (1984 - 1989)
** 1988 data left out of average computation due to apparent error in data (.53)

[13] Data is from 121.5 MHz ELT missions only.

As the table shows, there is a significant difference in notification time when the ELT worked and when the ELT did not work. When the ELT worked, the average time from LKP to AFRCC notification was 5.57 hours. When it did not, the average time was 12.34 hours. Unfortunately, only 25% of the old 121.5 MHz ELTs work after a crash. The projected rate for the improved 121.5 MHz ELT is 73%. An even greater improvement can be expected from the use of 406 MHz ELTs. When a 121.5 MHz ELT signal is the only notification of an accident that the AFRCC receives, there is an additional delay due to the need for a second satellite pass before any action can be taken. The additional satellite pass is required to confirm that the ELT is still transmitting and to resolve the ambiguity of location.

When a 406 MHz ELT is employed the notification time can be reduced by the time between the first and second pass since the ambiguity of location is usually determined on the first satellite pass. In addition, the alert signal is known to be from an emergency beacon due to the coded data transmission. The GEOSAR satellite capability will provide almost instant notification of the alert and, with the ELT ID in the data base and/or location in the message, immediate action can be taken by the RCC to begin the Planning-Evaluation Stage.

3.2 PLANNING/EVALUATION STAGE

In any SAR operation, there is a period of time when information must be evaluated and a course of action decided. Only after this period are resources dispatched to locate and recover survivors. The 406 MHz ELT is expected to effect a significant decrease in the time the AFRCC spends in this stage.

The high incidence of false alarms/alerts with the current 121.5 MHz ELT has resulted in operational procedures that require the RCC coordinator to wait until additional information is received before committing resources. The RCC investigates the validity of an "alert" by requesting the FAA to check aircraft ELT reports and call airports within the vicinity of the alert location. When a possible distress situation is confirmed by the FAA, the RCC determines a search area and allocates resources.

The 406 MHz ELT with its unique beacon ID, improved accuracy and false alert eliminator will reduce the time spent evaluating and planning a search and rescue mission.

3.2.1 Impact of Identification Code on Planning/Evaluation Time

The unique identification code assigned to each beacon will rapidly provide "who" is in distress. With this information, the RCC can query FAA facilities for specific flight information. In coastal areas, the ID will provide immediate differentiation between aviation and maritime alerts. The U.S.

Coast Guard experience with 406 MHz EPIRBs[14] shows a dramatic reduction in the planning and evaluation time. In addition, the number of false alarm missions will be reduced.

3.2.2 Impact of Improved Accuracy on Planning/Evaluation Stage

The increased accuracy of the 406 MHz ELT will generally reduce the "search area" from 1300 square Km to less than 13 square Km. As a result, the amount of resources required to search for the aircraft will be reduced.

3.2.3 Impact of Eliminating Interferers as Possible Distress Alerts

Noise or other RF radiation cannot produce false "alerts" since a valid 406 MHz ELT/EPIRB signal must pass the required ID check.

3.3 SEARCH STAGE

The time required to search and locate a downed aircraft depends on ruggedness of the terrain and the size of the search area. The more rugged the terrain, the longer it will take to search the area to achieve a high probability of locating the crash. The larger the search area, the greater the time required to search it. The size of the area is influenced by the type of ELT employed. When 406 MHz ELTs are in use, the reduction of the search area by a factor of 100 will reduce the amount of search resources needed and the time required to locate the downed aircraft.

4.0 APPROACH TO DERIVING BENEFITS

The benefits to be obtained from the use of 406 MHz ELTs vice the 121.5 MHz ELTs will result from.

- Increased ELT Survivability
- Reduction of the Search and Rescue Mission Stages
- Reduction of Resources used for SAR Missions and for Handling False Alarms

The first two are analyzed below in terms of " lives saved," while the third is analyzed in Section 5.1 in terms of cost savings.

4.1 INCREASED ELT SURVIVABILITY

A paragraph by paragraph comparison (Appendix A) was made between the specification requirements contained in RTCA DO-183 (121.5 MHz ELTs) and DO-204 (406 MHz ELTs). The

[14] The EPIRB is the maritime version of the ELT. Its RF characteristics are identical to those of the ELT.

improvements/enhancements expected by DO-204 were noted. Following this comparison, each specification improvement was examined by a team of experts[15] to assess the impact on the "Reason for Failure" shown in Table 7 of the NASA ELT study. The team of experts concluded that implementation of the DO-204 specification would result in improvements in three areas: Fire Damage, Impact Damage and Internal Failure.

Table 2 shows the degree of improvement in each of the three areas identified above. Table 3 shows the projected reduction in the number of failures when the 406 MHz ELT is employed. **The expected ELT survival rate for 406 MHz ELTs is 81%.**[16]

4.2 REDUCTION OF THE SEARCH AND RESCUE MISSION STAGES

Three months of mission folders (484 missions) from the AFRCC were analyzed to develop a baseline for detailed analysis of the current mission stages for 121.5 MHz ELTs. The times for each stage of the mission were plotted in histogram form so that the average time could be computed without being skewed by exceptional cases. Analysis of the mission folders was also used to validate our understanding of the actions taken at the RCC before a mission was launched. **The intent of this portion of the study is to estimate improvements to personnel survivability when a 406 MHz ELT is used.**

4.2.1 Notification Stage

The notification stage can be divided into two time periods: 1) the time from the distress occurrence to the first Cospas-Sarsat alert and 2) the time between the first alert and the "merge."[17] The first period is a function of the number of satellites and the geometry of the distress transmitter; therefore, the 406 MHz ELT cannot offer any improvement in the low orbit satellite case. However, the GEOSAR system can virtually eliminate this time period.

A time savings in the second time period can be realized by the 406 MHz Cospas-Sarsat low orbit satellite system. Figure 1 shows a histogram derived from the AFRCC records of 121.5 MHz missions for the time between the first alert and the merge of data from the second pass .

The average time between first alert and merge is **1.8 hours**. Since the 406 MHz system resolves the ambiguity in over 95% of the cases on the first pass and since the ID in the message identifies the signal as coming from either an ELT or an EPIRB, the RCC can start working the mission when the first alert is received. **As a result, 1.8 hours will be saved by the 406 MHz system.**

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[15] The team of experts consisted of former members of the ELT RTCA committee, including an experienced crash investigator and an experienced Search and Rescue Operations Officer.

[16] New survival rate = 1 - new failure rate = 1 - .27(331)/481, where .27 is the failure rate for the 121.5 MHz (TSO C91a) ELT.

[17] Two satellite passes must be available so that the ambiguity of the Doppler location can be resolved. No action can be taken by the RCC on the first alert because of the ambiguity factor and the large number of false alerts. The "merge" refers to the combination of data from the two satellite passes.

TABLE 2
Expected Additional Improvements from the Use of 406 MHz ELTs

EXPECTED IMPROVEMENTS FROM RTCA DO-183 (Table 6 of NASA Study*)			ADDITIONAL IMPROVEMENTS FROM RTCA DO-204	
REASONS FOR ELT FAILURE	**EXPECTED IMPROVEMENT %**	**APPLICABLE* IMPROVEMENTS**	**Expected Improv. %**	**APPLICABLE* IMPROVEMENTS**
1. Insufficient G's	95%	A.7, A.9, B.2, D.8, E.1, E.4		
2. Improper installation	95%	E.1, E.3, E.4, E.5		
3. Battery dead	95%	A.9, E.5, E.6		
4. Battery corroded	50%	A.10, E.5		
5. Battery installation incorrect	45%	A.9, E.2, E.3, E.4, E.5		
6. Incorrect battery	75%	E.3, E.4, E.5		
7. Fire damage	10%	B.3, B.4, D.14, D.15	50%	B6
8. Impact damage	75%	B.1, B.2, B.3, B.4	85%	B1,B3,B4
9. Antenna broken/disconnected	85%	B.2, B.5		
10. Water submersion	0			
11. Unit not armed	98%	A.9, E.1, E.2, E.4, E.5		
12. Shielded by wreckage	10%	A.3		
13. Shielded by terrain	10%	A.3		
14. Internal failure	75%	B.2, B.3, B.4, C.2, D.1, D.9, D.10, D.11, D.12	85%	A11,B1,B3,C2,C9, D1,D4
15. Signal direction altered by terrain	10%	A.3		
16. Packing device still installed	98%	E.1, E.3, E.4, E.5		
17. Remote switch off	100%	E.1, E.2, E.4, E.5		

*** The paragraph numbers listed in the Applicable Improvements column refer to the ELT Performance Specifications Comparison chart in Appendix A of this report. The paragraphs identified provide the basis for predicting the expected percent improvement for each reason of ELT failure.**

TABLE 3
Expected Additional Performance Improvement Using 406 MHz ELTs

From Table 7 NASA Report
Analysis of 1319 ELT Failures (where data was available) 1983-1987 and Expected Improvement from TSO-C91a and Expanded Inspection/Maintenance Program

ADDED IMPROVEMENT IN PERFORMANCE WITH 406 MHZ ELTS

REASONS	# OF ELT FAILURES	EXPECTED IMPROVEMENT %	EXPECTED # OF ELT FAILURES	EXPECTED IMPROVEMENT WITH 406 MHZ %	EXPECTED NUMBER OF FAILURES WITH 406 MHZ ELTS
1. Insufficient G's	245	95%	12		12
* 2. Improper installation	12	95%	1		1
* 3. Battery dead	42	95%	2		2
* 4. Battery corroded	2	50%	1		1
* 5. Battery installation incorrect	3	45%	2		2
* 6. Incorrect battery	4	75%	1		1
7. Fire damage	280	10%	252	50% (Fire Damage)	140
8. Impact damage	356	75%	89	85% (Impact Damage)	53
9. Antenna broken/disconnected	180	85%	27		27
10. Water submersion	62	0	62		62
*11. Unit not armed	70	98%	1		1
12. Shielded by wreckage	17	10%	15		15
13. Shielded by terrain	9	10%	8		8
14. Internal failure	14	75%	4	85% (Internal Damage)	2
15. Signal direction altered by terrain	4	10%	4		4
*16. Packing device still installed	3	98%	0		0
*17. Remote switch off	16	100%	0		0
Current Total of ELTs not Activated	1,319				
Expected Total of ELTs not Activated			481		331

* Preventable with an Expanded Maintenance/Inspection Program

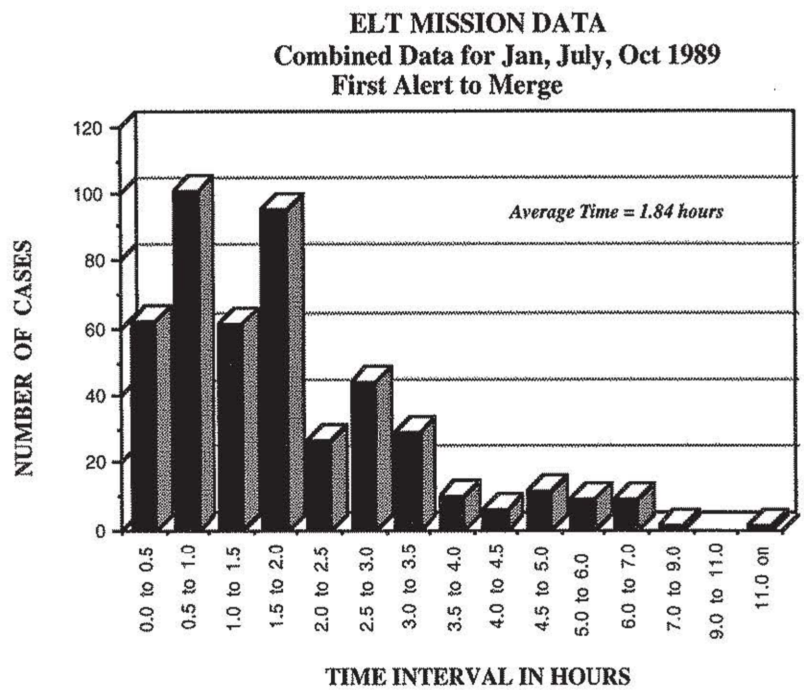

Figure 1. Distribution of Times from First Alert to Merge[18]

4.2.2 Planning/Evaluation Stage

The planning/evaluation stage can be divided into two time periods. The first time period is between ambiguity resolution and when the mission is opened. The second time period is from the time the mission is opened to when the aircraft are launched. The latter is not expected to improve with the use of the 406 MHz ELT.

The first time period can be greatly reduced when 406 MHz ELTs are used. It was determined from the analysis of AFRCC 121.5 MHz mission folders that the average time from ambiguity resolution to "mission opened" was **3.9 hours**. Figure 2 shows the distribution of this time period. This time is spent primarily on communications checks to attempt to determine if the "distress location" is from a real ELT or EPIRB and if a real emergency exists. This effort involves numerous cross checks with the FAA to obtain overflying aircraft reports and with airports in the vicinity to attempt to isolate the location of the transmitter.

This extensive cross checking with a number of sources is necessitated by the large number of false alerts and false alarms, as well as the fact that the location accuracy obtained from 121.5 MHz ELTs

[18] The data in Figures 1 through 3 were derived from the AFRCC Mission Records for the months of January, July and October 1989 to take into account the various seasons.

can include a number of airports within a metropolitan area of uncertainty. The U.S. Coast Guard's experience using a 406 MHz EPIRB has demonstrated **that a savings of approximately 3.2 hours can be achieved in ELT searches.**[19]

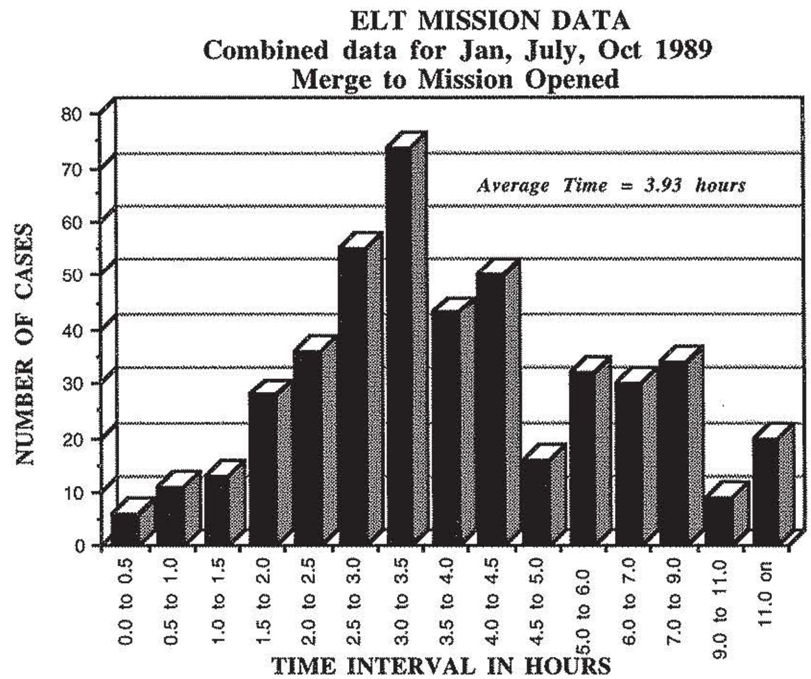

Figure 2. Distribution of Times from "Merge" to "Mission Opened"

4.2.3 Search Stage

Data from the AFRCC 121.5 MHz mission folders indicates that the average time spent during this stage is 2.2 hours. Figure 3 shows a histogram of the data from the AFRCC mission folders. Civil Air Patrol (CAP) personnel who have conducted 121.5 MHz ELT searches conservatively estimate it would only take .5 hours to locate a 406 MHz ELT signal. **This assumption would mean a reduction of 1.7 hours in the 121.5 MHz timeline.**

[19] If the Coast Guard data is used as a ratio to determine the time required for 406 MHz missions in the inland area, then the USAF savings equals 3.93 - (3.93 x .5) / 2.7, where 2.7 and .5 are the USCG average 121.5 MHz and 406 MHz times to open a mission respectively.

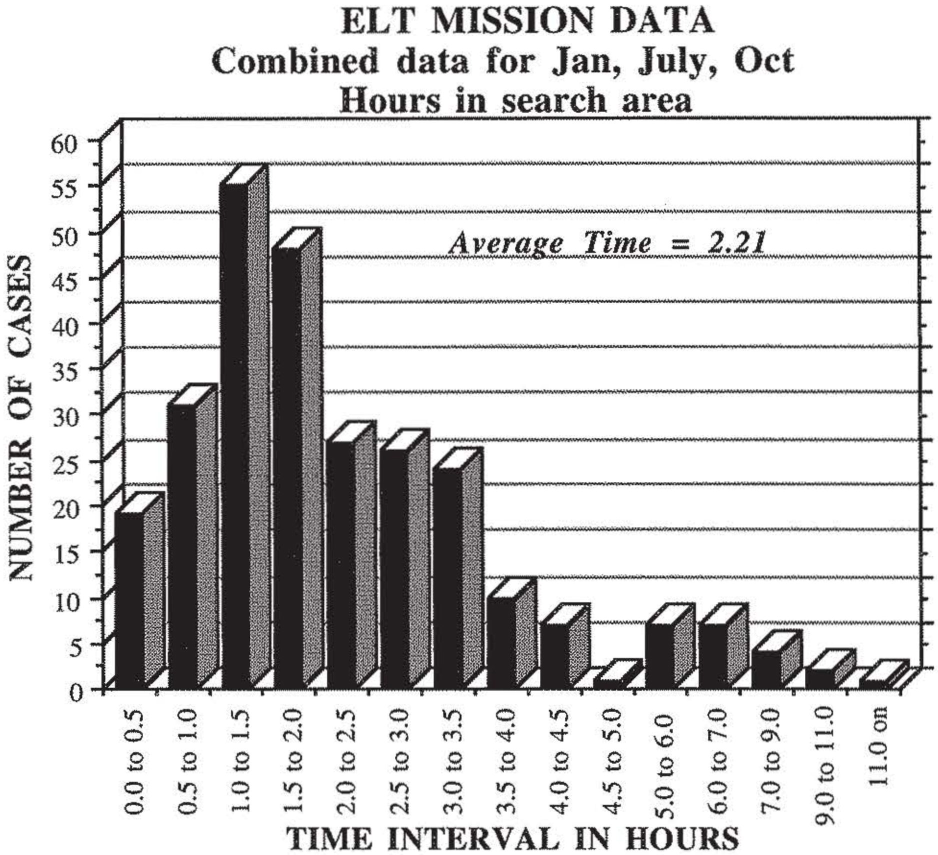

Figure 3. Histogram of Search Times from Three Months of AFRCC Mission Folders

4.2.4 Total Timeline Reduction

By adding the estimated time saved in each phase of the SAR mission, **the total time saved is 6.7 hours**, derived as follows:

Saving from first Alert to Ambiguity Resolution	1.8 hours
Saving in Mission Planning	3.2 hours
Saving in Search time	1.7 hours
TOTAL	6.7 hours

4.2.5 GEOSAR Alerts

Reduction in the SAR timeline can be expected in most cases when the alert is received through a GEOSAR satellite. This results because the registration data base contains points of contact (owner, marina, airport, etc.) to allow the RCC to take immediate action to determine the validity of the alert. This action can be taken without waiting for the low orbiting satellites to provide a location of the signal. It is estimated that **a GEOSAR 406 MHz alert would save 1.6 hours from the SAR timeline.**

4.2.6 Derivation of Lives Saved from SAR Timeline Reduction

Figure 4 shows Survival versus Time curves which were drawn from data presented in a DOT study[20] and in a Coast Guard Study.[21] The DOT survival curve has been further supported by DeHart and Beers [22] which states: "Within the first 8 hours the survival rate is more than 50%. Should a rescue be delayed beyond 2 days, however, the survival rate drops to less than 10%." Figure 4 also shows a curve based upon actual data from NTSB accident reports.[23] Although this curve is displaced in time from the DOT curve, the slope is parallel to the curves from the DOT study and the Coast Guard Study. The improved survivability of 50% (vice 34% when 121.5 MHz ELTs are used) is derived from the reduction in the SAR timeline when 406 MHz ELTs are used with the Cospas-Sarsat low orbit system. This indicates an improvement in survivability of 16% derived by a reduction in the timeline (6.7 hours due to the advantages of the 406 MHz ELT) and projecting the new average time to rescue on the "survival time" curve. In those cases where a GEOSAR alert is received, with beacon registration in the registration data base, the estimate of survivability is 64% (for an additional increase in survivability of 30% over 121.5 MHz ELTs).

5.0 STUDY RESULTS

As discussed in Chapter 4, the benefits to be obtained from the use of 406 MHz ELTs will be derived from three areas: 1) improved survivability; 2) reduction in the SAR timeline; and 3) improved SAR operations including the handling of false alarms.

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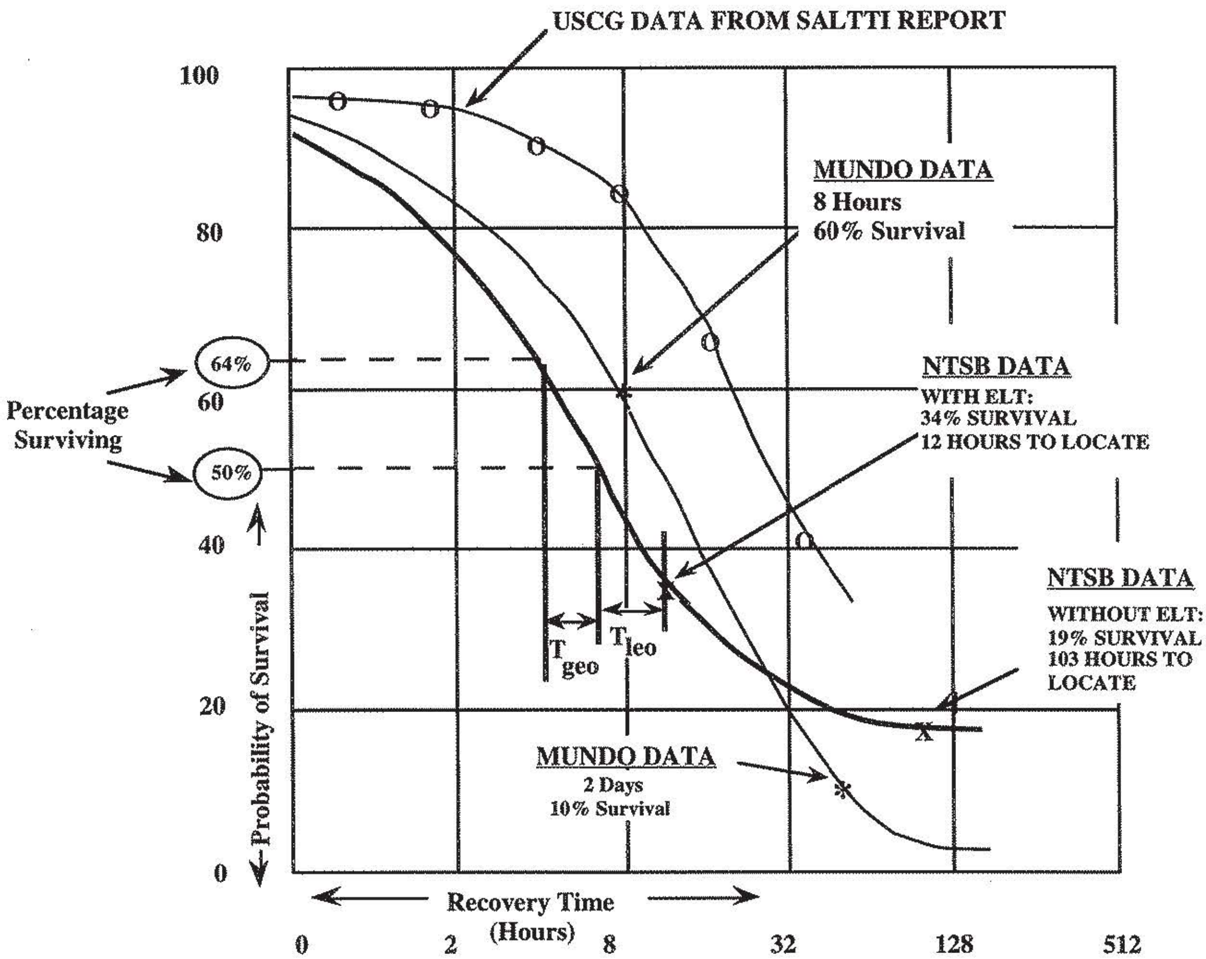
[20] DoD & NSC data given in C. Mundo, L. Tami & G. Larson, Final Report Program Plan for Search & Rescue Electronics Alerting and Locating System, DOT-TSC-73-42, February 1974.
[21] US Coast Guard Cost Benefit Analysis, Study of Alerting and Locating Techniques and Their Impact, by Computer Sciences Corporation, 18 September 1975.
[22] DeHart RL, Ed. Fundamentals of Aerospace Medicine, Philadelphia: Lea & Febinger, 1985: 862-67.
[23] NASA Contractor Report 4330 entitled "Current Emergency Locator Transmitter (ELT) Deficiencies and Potential Improvements Utilizing TSO-C91a ELTs", October 1990



LEGEND

T_{leo} = Timeline saving due to use of 406 MHz ELTs = 6.7 hrs using COSPAS-SARSAT LEO system

T_{geo} = Timeline saving due to use of 406 MHz ELTs = 1.6 hrs using 406 MHz GEO system

REFERENCES:

DOD & NSC data given in C. Mundo, L. Tami & G. Larson, Final Report Program Plan for Search & Rescue Electronics Alerting and Locating System, DOT-TSC-OST-73-42, February 1974.

U.S. Coast Guard Cost Benefit Analysis, Study of Alerting Locating Techniques and Their Impact (SALTTI), 18 September 1975, pg. 4-29, Table 4-11.

Figure 4: Survivability in Aircraft Crashes Projected from Use of 406 MHz ELTs Based on NTSB Data

5.1 BENEFIT FROM IMPROVED ELT SURVIVABILITY

Paragraph 4.1 discussed the improved survivability of the 406 MHz ELT (81%) vs. the improved 121.5 MHz ELT (73%) which would translate to additional lives saved per year if 406 MHz ELTs were in general use. The results contained in Chapter VII of the NASA study were used as a basis. The number of searches with Supplement M data was normalized to reflect the actual number of searches conducted each year (based on AFRCC and CAP data) which doubled the number of people involved. In the NASA study it was projected that approximately 25 lives per year could be saved (page 29) using improved 121.5 MHz ELTs. This projection took into account an adjustment due to lack of Supplement M data in half of the search missions.

The benefits from improved ELT survivability are a reduction in SAR operations costs (as shown in Table 4) and the additional lives saved. These benefits result from turning non-ELT search missions into ELT search missions and the increased survivability of the occupants due to the decrease in the SAR timeline. **Appendix B provides a detailed analysis of the lives to be saved.**

5.2 BENEFIT FROM REDUCTION IN THE SAR TIMELINE

Paragraph 4.2 developed the rationale for reducing the average SAR timeline using the operational performance advantages of the 406 MHz system. It was shown that 6.7 hours could be saved using the Cospas-Sarsat 406 MHz Low Earth Orbit (LEO) system and an additional 1.6 hours could be saved using the 406 MHz GEOSAR system. This time saving was projected on the probability of survival versus time to rescue curve and the result was shown to be an increase from 34% to 50% survivability **(an increase of 16% over the 121.5 MHz ELTs)** with the 406 MHz LEO system and 64% survivability **(an increase of 30% above 121.5 MHz ELTs)** with the GEOSAR system. The analysis in Appendix B takes into account the people that could be saved in past cases where the ELT worked

TABLE 4
Resources Saved by Complete Retrofit with Improved 121.5 MHz ELTs or 406 MHz ELTs

12/3/93

	DESCRIPTION OF SAVING	IMPROVED 121.5 MHZ ELT	406 MHZ ELT	NOTES
USAF/CAP	IMPROVED ACTIVATION RATE CONVERTS A/C SEARCHES TO ELT SEARCHES (1)	123 SEARCHES (2) 7503 HRS $487,695	143 SEARCHES (3) 8723 HRS $566,995	AVERAGE OF 192 MISSIONS/YR. $65 /HR OF CAP FLYING TIME
USAF/CAP	SAVING IN FALSE ALARM COSTS CURRENTLY AVG. 1970 MISSIONS/YR (4)	REDUCTION BY 75% IN 46% OF MISSIONS 680 MISSIONS (5) 1088 HRS = $70,720	SAME REDUCTION AS C91a PLUS 80% OF 54% OF MISSIONS (6) 1531 MISSIONS 2450 HRS= $159,250	AVERAGE CAP FLYING TIME PER MISSION =1.6 HRS; COST = $65/HR
USAF/CAP	SAVING OF FEDERAL RESOURCES (C-130 & HELIC.) AVG. 2 HRS/MISSION	123 MISSIONS 246 HRS $369,000	143 MISSIONS 286 HRS $429,000	C-130= $1800/HR HELICOP= $1200/HR AVG.=$1500/HR
USAF/CAP	CAP PERSONNEL SAVINGS FROM IMPROVED ACTIVATION RATE	97,539 HRS $1,170,468	113,399 HRS $1,474,107	$12/HR 13 PERSONS/MISSION
USAF/CAP	CAP PERSONNEL SAVINGS FROM IMPROVED FALSE ALARMS	4080 HRS $48,960	9312 HRS $111,744	$12/HR 3 PERSONS/MISS.
USCG	IMPROVED ACTIVATION RATE CONVERTS NON-ELT MISSIONS TO ELT MISSIONS (48 LAND CASES/YR.)	35 OUT OF 48 LAND CASES EACH YR. DELTA OF $12,073/ CASE SAVING = $422,555 (2)	39 OUT OF 48 LAND CASES EACH YEAR DELTA OF $12,073 / CASE SAVING = $470,847 (3)	USCG SEARCH COSTS W/O ELT= $18,305/CASE WITH ELT= $6,232/CASE DIFFERENCE = $12,073
USCG	SAVINGS IN FALSE ALARM COSTS	75% REDUCTION IN FALSE ALARM MISSIONS (72 OUT OF 96 TOTAL) SAVING = $225,072	SAME REDUCTION AS C91a PLUS 80% (7) REDUCTION OF OTHERS 91 MISSIONS = $284,466	USCG COST OF HANDLING FALSE ALARMS IS $3,126 PER CASE
	SAVING IN NOAA COMMUNICATIONS COSTS FOR ALERT MESSAGES	MINIMAL	≥ $100,000	ELIMINATION OF FALSE ALERTS, SPURIOUS & IMAGES
	TOTAL RESOURCES SAVED	**$ 2,794,470**	**$ 3,596,409**	**DELTA $ 801,939**

NOTES
1. Based on 6 yr. average of AFRCC missions for actual missing aircraft without ELT; 192 missions/yr. and 12,033 hrs. flown by CAP
2. Assumed ELT activation rate of 73%
3. Assumed ELT activation rate of 81%
4. Based on 6 yr. average of 1970 false alarm missions per year; 3071 hrs flown by CAP
5. False alarm cases where ELT was found in aircraft
6. With identification and beacon registration, Coast Guard has shown that 80% of false alarms can be handled by phone.
7. 80% of false alarms can be handled by telephone without launching a mission

5.3 SUMMARY OF LIVES TO BE SAVED WITH 406 MHZ ELTS

There are two basic factors that affect the life saving capability of the 406 MHz ELT: **improved survivability** of the 406 MHz ELT in aircraft crashes and the **reduction in the SAR timeline.** (A detailed explanation of the rationale and determination of performance advantages and time saved by the 406 MHz ELT is given in Sections 2, 3 and 4 and Appendix B.)

POTENTIAL FOR LIVES SAVED USING 406 MHZ ELTS[24]

FROM IMPROVED ELT SURVIVABILITY AND REDUCED TIMELINE	**81 LIVES PER YEAR**[25]
FROM REDUCED TIMELINE IN CASES WHERE ELT WORKED IN THE PAST	**53 LIVES PER YEAR**
TOTAL	**134 LIVES PER YEAR**

5.4 REDUCTION OF SAR RESOURCES

As discussed in Chapter 3, there are many features of the 406 MHz system which will improve SAR operations. A number of these features will not only improve SAR operations in distress cases, but will also help to prevent and/or mitigate the problems of false alerts and false alarms.

5.4.1 Resources Saved by Reducing the Number of Non-ELT Missions

The improved activation rate of the 406 MHz ELT results in 143 of the 192 aircraft missions per year being converted from non-ELT missions to ELT missions. [26] The resultant savings by the United States Air Force (USAF)/CAP and the United States Coast Guard (USCG) are shown in Table 4 and compared to the savings from the improved 121.5 MHz ELT.

5.4.2 Savings in NOAA Communications Costs

As a result of the elimination of ELT false alerts, the communications costs for NOAA will be reduced by approximately $100,000 according to experts in the Sarsat Operations Division of NOAA (as shown in Table 4). There will be no savings expected from the use of improved 121.5 MHz ELTs.

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[24] Data reflects reduction of 10% in potential lives to be saved due to adverse weather conditions that would prevent rescue despite timely notification.
[25] Data reflects saving 3 Civil Air Patrol lives each year which are now lost during searches for aircraft crashes where no ELT was operating.
[26] Aircraft missions are searches for missing aircraft where no ELT is transmitting. ELT missions are searches for a transmitting ELT which could be a distress or a false alarm.

5.4.3 Resources Saved From Improved False Alarm Mitigation

False alerts will be eliminated due to the coding of the message.[27] In addition, problems with false alarms will be mitigated due to the greater ease of handling the 406 MHz alerts. The features in the 406 MHz system which will lead to mitigation of false alarms are:

1) Identification in the Message and
2) the Accuracy of Location.

5.4.3.1 Identification (ID) in the Message. The use of ID in the message will completely eliminate false alerts from sources other than an emergency beacon as the satellite will not recognize or process RF signals that are not appropriately coded. In addition, the message will allow the RCC controllers to know the type of aircraft (e.g., airliner or small plane) and will allow communications checks with the owner, home airport or other points of contact to determine if an emergency exists.

5.4.3.2 Accuracy of Location. The accuracy of location (within approximately 2 Km) will be of particular help when valid data base information is not available. This accuracy should allow the RCC to contact the closest airport (within the 13 square kilometers) to see if the signal is originating from an airport (e.g., from an aircraft or an avionics shop). This is greatly improved over the case of 121.5 MHz alerts where there could be a number of airports within the 1,300 square kilometers location accuracy.

5.4.3.3 Assumptions for Saving Resources in Handling ELT False Alarms. The NASA Study estimated a reduction in false alarms by 75% due to the improvements in the 121.5 MHz ELT. This improvement applies to ELTs mounted in aircraft and does not cover false alerts from other sources. If we assume that the Coast Guard experience in silencing 406 MHz false alarms (80% silenced without launching a mission) will be similar in the inland area, we have a basis for forecasting the savings due to using the 406 MHz ELTs. In addition to eliminating 80% of the false alarm/false alert SAR missions, the cost of the remaining false alarm missions will be dramatically reduced by the timeline saving discussed in Paragraph 4.2. The saving of resources from improved handling of false alarms with the 406 MHz system are shown in Table 4 "Resources Saved by Complete Retrofit with Improved 121.5 MHz ELTs or 406 MHz ELTs." Cost reductions are projected for USAF/CAP operations, savings of federal resources and savings in NOAA communications costs.

5.4.4 USAF/CAP Savings

Table 4 projects USAF/CAP operational savings in three areas: SAR operations, use of federal resources and CAP personnel savings. These savings are the benefit of the improved ELT activation rates that will convert aircraft searches to ELT searches, and reduced false alert/alarm processing that will reduce the need for federal resources and CAP personnel.

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[27] Identification as a distress message is required for the Cospas-Sarsat system to accept the message; therefore, RF signals from other sources will not be treated as an alert.

5.4.4.1 Savings from Improved Activation Rates. Currently, when distress situations not involving ELTs occur, SAR operations are conducted by aircraft visual searches that survey flight plan areas looking for downed aircraft. Analysis of AFRCC Annual SAR reports for the period 1987 through 1992 shows an average of 192 of this type of mission occurred per year. This resulted in an annual average of 12,033 hours of flight time. At a USAF/CAP cost of $65 per hour of flight time, the cost associated with using aircraft for non-ELT missions resulted in an average annual cost of $782,145. Table 4 shows that increased ELT survivability projections (81% activation with 406 MHz ELTs vs. 73% activation with improved 121.5 MHz ELTs) will convert 123 searches (in the case improved 121.5 MHz ELTs) and 143 searches (with 406 MHz ELTs) to ELT missions for substantial cost savings. The table also shows that the reduction of 123 aircraft searches (for improved 121.5 MHz ELTs) or 143 searches (for 406 MHz ELTs) would result in a reduction of federal resources (C-130 and helicopter) required.

5.4.4.2 Savings from Reduced False Alarm Processing. CAP mission folders were analyzed to identify and categorize the origin of false alarms that result in SAR activities. False alarm categories and percentages from that analysis are presented below.

Description	Percentage
a) Non-distress ELT on civil aircraft at airport or private landing site	**41.3%**
b) ELT/EPIRB AFRCC mission issued but no signal source found	25.7%
c) Non-distress EPIRB on boat or ship	08.3%
d) Non-distress ELT/EPIRB removed from aircraft or boat	08.2%
e) U.S. Government non ELT/EPIRB signals	07.3%
f) Non-distress ELT found on DoD aircraft of federal facility	**04.6%**
g) Civilian non ELT/EPIRB signals not coming from beacon source	04.6%

Review of this data shows that 46% of the missions (items a and f) would be helped by the use of improved 121.5 MHz ELTs. Table 4 shows that a reduction of 75% in false alarm processing for 46% of the cases would result in a savings of 1,088 hours or $70,720 per year. However, due to the positive identification data contained in the 406 MHz system messages, it was determined that the remaining 54% of the false alarm cases would be helped by implementation of 406 MHz ELTs. Using the USCG current success rate at resolving false alarms by telephone (80%), applied to those cases not helped by improved 121.5 MHz ELTs (54% of missions), cost savings in false alarm processing for the 406 MHz system were calculated at 2,450 hours or $159,250 annually. CAP personnel savings from improved false alarm processing are also shown in Table 4.

5.4.4.2 CAP Lives Saved by Reduction of Non-ELT Searches. According to CAP an average of three CAP persons lose their lives each year searching for crashes where no ELT is operating. There have been no lives lost in searches where an ELT was operating. Because of the improved activation rate of both the improved 121.5 MHz ELT and the 406 MHz ELT, the CAP feels that these lives will be saved.

5.4.5 USCG Savings

The average number of land SAR cases supported by the USCG was used to derive cost benefits associated with improved activation rates and reduced false alarm processing when the 406 MHz system is used. Table 4 shows that the projected activation rates result in a reduction of 35 USCG searches for 121.5 MHz ELTs and 39 USCG searches for 406 MHz ELTs, resulting in a cost savings of $422,555 and $470,847 respectively per year. Cost savings for reduced false alarm processing were calculated using the same formula used to derive USAF/CAP benefits.

6.0 CONCLUSIONS AND SUMMARY OF POTENTIAL BENEFITS

The saving of lives that can be expected from the use of 406 MHz ELTs vice the improved 121.5 MHz ELTs has been derived in Appendix B and summarized in Section 5 above. The lives saved are shown to be due to both an expected improvement in survivability of the 406 MHz ELTs (see Table B-1) and the reduction in the search and rescue timeline because of the improved operational capability of the 406 MHz satellite system (see Attachment 2 from Appendix B). The use of 406 MHz ELTs results in operational cost savings from the improved efficiency in SAR operations and in the handling of false alarms. In summary the replacement of all 121.5 MHz ELTs with 406 MHz ELTs is projected to provide the following benefits:

USE OF 406 MHz ELTs RESULTS IN A SAVINGS
OF
RESOURCES OF $3.6 MILLION PER YEAR
AND
134 LIVES PER YEAR, REPRESENTING
A TOTAL OF
$339 MILLION [28] SAVED PER YEAR

THE ADDED BENEFITS
OF
406 MHZ ELTS
OVER THE 121.5 MHZ ELTS IS AS FOLLOWS:

$802,000 SAVED PER YEAR IN OPERATING COSTS
AND
111 LIVES PER YEAR, REPRESENTING
A TOTAL OF
$278 MILLION SAVED PER YEAR

[28] Costs include resources saved and cost of lives saved at current cost/benefit accepted rates of $2.5 million per life.

APPENDIX A

COMPARISON OF ELT PERFORMANCE SPECIFICATIONS

RTCA DO-183 (121.5 MHz ELTs)

and

RTCA DO-204 (406 MHz ELTs)

A. PERFORMANCE REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
3. Frequency Stability	Para 2.2.2.1 Requires stability to be within ±0.005% under all environmental conditions.	Para 2.2.2.1, Table 2-4 Short Term: ≤ 0.002 Parts/million in 100 ms. Medium Term (15 min): Mean slope: ≤ 0.001 parts/million/min. Residual: ≤ 0.003 parts/million. Long Term: ±0.005 MHz within 5 years, including initial offset.	S+	More demanding frequency tolerances should result in greater system location accuracy, typically 1 – 2 km versus 15 – 20 km.
4. Peak Effective Radiated Power	Para 2.2.2.5 Reference 2.3.1.1 & 2.3.1.2 Requires the ELT to meet one of the following power/time combinations: (a) at least 50 mW (17dBm) over a 50 hour period. (b) at least 25 mW (14dBm) over a 100 hour period. (c) not less than any linearly extrapolated power level vs. time period between (a) and (b) above. In addition to (a), (b), or (c) above, the ELT may operate over a 50 hour period at −40° C with a PERP of at least 5 mW (7dBm).	Para 2.2.2.4 (Output Power) Para 2.2.2.5 (VSWR) Para 2.2.2.7 (Spurious Emissions) Reference Figure 2-4 Requires output power to be within limits of 5 watts ±2 dB measured into a 30-ohm load with a VSWR ≤ 1.25 : 1. Output power rise time shall not be less than 5 ms measured between 10% and 90% power points. Modulator and transmitter shall be able to meet all requirements except for output power at any VSWR between 1:1 and 3:1 and shall not be damaged by any load from an open circuit to a short circuit. Transmitter power output spectrum should remain within limits of Figure 2-4.	0	

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
4. Peak Effective Radiated Power (cont.)	Para 2.2.9 (Transmitter Turn-on) Reference 2.2.2.3 Requires that within 5 minutes of activation (auto or manual), the PERP shall be at least 50 mW (17 dBm) or that selected by the manufacturer.	Para 2.2.8 (Warm-up Time) Requires ELT to be capable of meeting all performance requirements within 15 minutes of activation.	0	Longer warm-up time for 406 beacon (15 minutes vs. 5 minutes) increases probability that the unit will function in extreme environments without significantly lengthening the period between activation and reaching full power.
5. Transmitter Modulation Characteristics	Para 2.2.2.2 (Audio Swept Tone) Requires emission to be type A9, having a distinct audio characteristic achieved by amplitude modulating the carrier with an audio frequency, sweeping downward over a range of not less than 700 Hz, within the range 1600 to 300 Hz, and with a sweep repetition rate between 2 and 4 Hz. The modulation factor shall be at least 0.85. Allows optional characteristics to improve SAR capabilities: (a) SAR Detection and Homing Capabilities - a burst of unmodulated CW power for a duration of 2.0 ±0.25 seconds and repeat the burst every 8.0 ±0.25 seconds. (cont. on next page)	Para 2.2.2.2 (Digital Message) Requires digital message generator to key modulator and transmitter with a repetition period of 50 seconds ±5% (so that any two transmitters will not appear to be synchronized closer than a few seconds over a 5 minute period) and a total transmission time of 440 ms ±1 percent (short message) or 520 ms ±1 percent (long message). The initial 160 ms ±1 percent of transmitted signal shall be an unmodulated carrier at the transmitter frequency (measured at the 90% power point); the final 280 ms ±1 percent of transmitted signal shall contain 112 bit message at rate of 400 bps ±1 percent (short message); (cont. on next page)	S+	Identification and global coverage enable early commencement of a SAR mission. DO-204 incorporates all requirements of C/S T.001 (Nov 88).

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
5. Transmitter Modulation Characteristics (cont.)	Para 2.2.2.2 (Audio Swept Tone) (cont.) (b) SAR Satellite Detection - provide clearly defined carrier with at least 30% of power within ±30 Hz of the carrier at 121.5 Mhz and ±60 Hz at 243.0 MHz. (c) Voice Modulation (A3) - is allowable provided it will not consume energy from the power supply at rate greater than normal ELT swept tone modulation (A9).	Para 2.2.2.2 (Digital Message) (cont.) the final 360 ms ±1 percent of transmitted signal shall contain 144 bit message at rate of 400 bps ±1 percent (long message). Requires bit synch pattern ("1's") to occupy first 15 bit positions. Requires frame synch pattern ("0 0010 1111"-normal or "0 1101 0000"-test) to occupy positions 16 through 24. Frame flag will be bit 25 ("0"-short message, "1"- long message), and remaining 87 bits (short message) or 119 bits (long message) are defined in C/S documents.		
6. Modulation Duty Cycle	Para 2.2.2.3 Requires modulation applied to carrier to have a minimum duty cycle of 33% and a maximum duty cycle of 55%. Emission designator is A9.	Para 2.2.2.3 Requires the carrier to be phase modulated 1.1 ±0.1 radians peak referenced to the unmodulated carrier. Rise and fall times of modulated waveform are required to be 150 microseconds ±100 microseconds. Emission designator is 16K0G1d.	N/A	Although the very short duty cycle (≈ 1%) of the 406 MHz transmission is not well suited to homing by aircraft, the beacon will be carried in conjunction with a 121.5/243.0 beacon.

[1] Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
7. Transmitter Duty Cycle	Para 2.2.2.3 Reference 2.2.2.2 Requires the transmission to not be interrupted, except as specified in para 2.2.2.2.	Para 2.2.2.2 Para 2.2.2.6 (Max Continuous Transmission) Requires repetition period of 47.5 to 52.5 seconds. Inadvertent continuous transmission be equipment failure shall be limited to a maximum of 45 seconds.	N/A	
8. Antenna Radiation Characteristics	Para 2.2.4 Requires that both the fixed and auxiliary antennas (if provided) shall radiate on 121.5 and 243.0 MHz. Radiation shall be vertically polarized and omni-directional in the horizontal plane, but only when the antenna is in its normal orientation.	Para 2.2.4 Allows circular (RHCP) or linear polarity. Requires antenna gain (antenna in normal mounting configuration and on ground plane of 1/2 wave-length radius) to be between -3 dBi and +4 dBi over 90% of following range: Azimuth: full 360° Elevation: 5° < *elevation* < 60°	0	Incorporates all requirements of C/S T.001 (Nov 88).

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
9. Automatic Crash Activation of Sensor	Para 2.2.3 Reference Figure 2–1 Requires the crash activation sensor to activate with a threshold force level of 2.0 ± 0.3 G's and a minimum velocity change of 3.5 ± 0.5 ft/sec (but not under less severs conditions) and when simultaneously subjected to 30 G's of cross-axis acceleration.	Para 2.2.3 Reference Figure 1–1 Same as DO–183	0	Carries DO–183 requirements forward, providing significant improvement to crash sensor which should yield an increase in number of crashes detected and a corresponding decrease in non-crash activations.
	Para 2.2.3c (Sensor Packaging) Reference 2.2.1 Requires, if the sensor is packaged as a separate unit, that no combination of short circuits and/or open circuits in the interconnecting wiring shall result in a reduction of operating life or in deactivation of the transmitter after it has been activated.	Para 2.2.3b Same as DO–183	0	

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

A. PERFORMANCE REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
9. Automatic Crash Activation of Sensor (cont.)	Para 2.2.3d (Crash Sensor/ELT Interface) Requires, if a separate unit is used, that the interface wiring is not required to survive the crash after it transmits the activation signal. Disconnecting the interface for maintenance shall not cause a false activation.	Para 2.2.3c Same as DO-183	0	
	Para 2.2.3e (Optical Sensors) Reference 2.2.3b & 2.2.1 Allows optional alternate crash sensors, and requires that switches must be mounted in sufficient numbers and locations to detect a crash as describe in 2.2.3b. Using operational parameters, such as engine pressure or engine vacuum to indicate crash situations is another acceptable method provided that ELT activation shall not occur during normal operational procedures and special action on the part of the pilot to disarm the device at the end of the flight is not required.	Para 2.2.3d Reference 2.2.3a Same as DO-183	0	Carries forward provision for alternate crash sensors with caveat that they not activate during normal operations and not require pilot action to disarm device at end of flight.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
10. Activation Monitor and Remote Control	Para 2.2.6 a & b Requires an aural and/or visual monitor (integral or separate from the ELT) to alert the pilot to the fact that the ELT has been activated and is transmitting. The aural monitor if not integral to the ELT must be installed in the aircraft and must have a minimum signal intensity level of 90 dBm measured 1 meter from the source. The visual monitor must be in view of the pilot's position, and it shall be visible under normal daytime ambient light conditions at 1 meter. Remote controls shall be provided if the local controls are not accessible from the pilot's position.	Para 2.2.6 a & b Requires both an aural and visual monitor to alert the pilot to the fact that the ELt has been activated. The aural monitor shall provide a distinct signal with a minimum intensity of 75 Dbm but not exceeding 85 Dbm at the pilot's position, and is required to operate when the aircraft's primary electrical system is "OFF". The visual monitor must be operable at all times and must be visible from the pilot's position under normal daytime ambient light conditions.	+	Aural and visual monitors are required with specific operational periods, improving pilot and ground crew capability to detect inadvertent transmitter operation.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
10. Activation Monitor and Remote Control (cont.)	Para 2.2.6c For both monitors, the remote control mode will be Manual On, Armed, and Reset. Off will not be available. Further requires that the power supply, either a dedicated or alternate power supply, may not detract from the ELT operating life. For fault tolerance, no combination of short circuits between the remote control, monitor(s), associated wiring and the airframe shall either inhibit the equipment from being automatically activated, or deactivated, or cause a power drain.	Para 2.2.6c Same as DO-183.	0	Remote control requirements of DO-183 are carried forward enhancing potential for pre-flight detection that ELT is not armed. Facilitates ground crew deactivation of inadvertent ELT transmissions when ELT is not located in the cockpit area.
11. Power Supply	Para 2.1.11 Requires that gas or liquid seepage from power supply shall not effect internal ELT components (separation of battery compartment from electronics within ELT case).	Para 2.1.12 (Battery) Requires that ELT not be hazardous to personnel and that toxic or corrosive products not be released outside the case during or following storage at temperatures between −55° C and +85° C. If fluids can be vented, they must be contained so that they shall not effect internal ELT components.	+	Prevents corrosion electronics due to fluid leakage. Enhances safety of personnel handling or servicing ELTs.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
12. Self Test	Not Addressed	Para 2.1.9 The ELT shall include a self test designed to test, as a minimum, the capability of the battery to power the unit and to activate the cockpit ELT monitor. Any modulated signal transmitted from the ELT during the self test shall have a special frame synchronization pattern and shall not transmit more than one burst to ensure that the signal is not processed by the satellites.	+	Adds requirement for a self test capability which will adequately test the ELT and not generate a false alarm position.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

B. CRASHWORTHINESS

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
1. Shock Impulse Survival Level	Para 2.3.4.1 Requires that ELT must survive 1 shock impulse of 500 G's (4 ± 1 ms duration) in each of six directions. This impulse is based on aircraft impact velocities of 190 mph.	Para 2.3.4.1 Reference 2.4.2.4 Requires that ELT be operating and that ELT must continue to operate following a shock impulse of 500 G's (4.0 ± 1.0 ms duration) in each of six directions and then continue to operate following a shock pulse of 100 G's with a duration of 23.0±2.0 ms.	+	Adds requirement for ELT to be operating during test and adds second test at 100 G's. Should significantly improve ELT survival following a crash.
2. System Integrity Associated with Crashworthiness	Para 2.2.5 Reference 2.4.2.4 Requires that attachment and/or mounting normally used to mount the ELT in the aircraft shall withstand a shock test of 100 G's in all directions in the non-operating mode without the ELT breaking loose, damaging the equipment, or otherwise resulting in the ELT's not being able to activate.	Para 2.2.5 Reference 2.4.2.4 Same as DO-183	0	Improves survivability of ELT in its mount.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
3. Crash Protruding Survivability	Para 2.3.4.2 Requires that ELT withstand a drop of 25 kg (55 lb) mass with a penetrator of 0.64 cm (0.25 in) x 2.5 cm (1 in) from a height of 15 cm (6 in) on the most vulnerable area of three or four required areas of the ELT.	Para 2.3.4.2 Requires that ELT be operating during test and that ELT continue to operate following test. Actual test requirements/procedures are same as DO-183.	+	Requirement for ELT to be operating during test is more restrictive than DO-183 and should result in a more survivable ELT.
4. Crash Pressure Survivability	Para 2.3.4.3 Requires that ELT must withstand a crushing pressure of 6.9×10^5 newtons per m^3 (100 psi) not to exceed 450 kg (1000lb) successively over three or four required surface areas of the ELT.	Para 2.3.4.3 Requires that ELT be operating during test and that ELT continue to operate following test. Actual test requirements/procedures are same as DO-183.	+	Requirement for ELT to be operating during test is more restrictive than DO-183 and should result in a more survivable ELT.
5. Antenna and Coaxial Cable	Para 3.1.10 & 3.1.11 Provides specific requirements for antenna polarization (vertical); proximity of externally mounted antenna to ELT (3.1.10.2); static load test of 100 x weight (3.1.10.3); internal antenna installation (3.1.10.4); and cable installation (3.1.11) requiring slack in cable, application of fires resistant material around cable, and prohibiting cable installation across aircraft production breaks.	Para 3.1.10 & 3.1.11 Same as DO-183 with exception of antenna polarization which can be either circular (RHCP) or linear.	0	Provides greater potential for antenna and interconnecting cables to survive a crash.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
6. Fire Protection	Para 2.1.5 Requires that except for small parts that would not significantly contribute to propagating a fire, all materials used shall be self extinguishing.	Para 2.3.7 Requires that except for small parts that would not significantly contribute to propagating a fire, all materials used shall be self extinguishing, and that ELT is expected to survive post-crash fires. (a) All ELTs will be subjected to a flame test by placing the ELT directly over the center of a fire tray at a height of $1m \pm 0.025$ m (39 ± 1 inch) for a minimum of 15 seconds. (b) AF type ELTs will be subjected to a fire test of at least 1100° C, producing a thermal flux of $20W/cm^2$ for a continuous and uninterrupted period of at least 2 minutes. After removal from the flame or fire test, the equipment will be allowed to cool naturally and then meet the aliveness test.	+	Provides a specific requirement and establishes tests for post-crash fire survivability yielding a more reliable ELT that will operate following a post-crash fire.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
1. Radio Frequency Intermodulation	Para 2.2.7a-b Reference 2.4.2.6, Figures 2-2, & 2-3; Tables 2-1 & 2-2 When the ELT unit is in the Armed mode, the application of any two frequencies in the 54-108 MHz band at +10 to +14 dBM to the ELT shall not result in reradiation of a third frequency in the 108-137 Mhz band exceeding the following levels: (a) direct coupling to the RF output terminal - the third frequency shall not exceed 83 dBm. (b) radiation coupling to external surface of the aircraft test configuration - shall not result in a third field with an intensity greater that 7 microvolts/meter at an appropriate receiving antenna 2 meters from the ELT antenna.	Not Addressed	N/A	Intermodulation is not considered a factor with the 406 MHz Beacon.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

C. ELECTROMAGNETIC ENVIRONMENT REQUIREMENTS

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
2. Radio Frequency Susceptibility (not applicable to ELT (S))	Para 2.2.8 When the ELT unit is in the Armed mode, it shall not be activated or damaged when a signal in the 108–137 MHz band a +23 dBm is directly coupled to the ELT antenna terminal of for ELTs that employ externally mounted antennas, when a vertically polarized electromagnetic field of 9.6 volt/meter is applied to the external surface of the aircraft test configuration.	Para 2.2.7 & 2.3.17 Reference DO–160C, Section 20 When the ELT unit is in the Armed mode, it shall not be activated or damaged when a signal in each of the 108–121 MHz, 122–137 MHz and 420–460 MHz bands at a +23 dBm level is directly coupled to the ELT antenna terminal or for ELTs that employ integrally–mounted antennas, when a vertically polarized electromagnetic field of 200 volts/meter is applied to the external surface of the aircraft test configuration.	+	Reduces the potential for internal failures of the ELT and false activations due to external, high power transmissions. Adds additional conditional requirement of RTCA/DO–160C.
3. Normal Variation of the Electrical Power Supply Inputs	Para 2.3.12.1 Reference 2.2.6 & DO–160A, 16.5.1 and/or 16.5.2 If applicable, the ELT Remote Monitor shall operate and meet "Activation Monitor" requirements (para 2.2.6) under normal variation (surges, peaks, or ripple voltage variations, interruptions, etc.) of the aircraft electrical system, as specified in 16.5.1 and/or 16.5.2.	Para 2.3.13.1 Reference 2.2.6 & DO–160C, 16.5.1 and/or 16.5.2 Same as DO–183.	0	Reduces the potential for electrical power variations to cause inadvertent activation of remote monitor.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
4. Abnormal Conditions of the Electrical Power Supply Input	Para 2.3.12.2 Reference 2.2.6 & DO-160A, 16.5.3 and/or 16.5.4 If applicable, the ELT Remote Monitor shall withstand abnormal conditions of the aircraft electrical system, as specified in 16.5.3 and/or 16.5.4.	Para 2.3.13.2 Reference 2.2.6 & DO-160C, 16.5.3 and/or 16.5.4 Same as DO-183.	0	Same as above.
5. Voltage Spike Protection	Para 2.3.13 Reference 2.2.6 & DO-160A 17.3 (Category A) or 17.4 (Category B) If applicable, the ELT Remote Monitor shall withstand the effect of voltage spikes arriving on its power leads as specified in 17.3 or 17.4. The ELT shall not activate as a result of these tests.	Para 2.3.14 Reference 2.2.6 & DO-160C 17.3 (Category A) or 17.4 (Category B) Same as DO-183.	0	Reduces the potential for electrical power variations to cause inadvertent activation of remote monitor.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

C. ELECTROMAGNETIC ENVIRONMENT REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
6. Conducted Audio-Harmonics Susceptibility	Para 2.3.14 Reference 2.2.6 & DO-160A, Section 18 The ELT Remote Monitor shall operate and meet "Activation Monitor" requirements when it is subjected to audio frequency components that are harmonically related to the power supply fundamental frequency as specified in Section 18. The ELT shall not activate under these conditions.	Para 2.3.15 Reference 2.2.6 & DO-160C, Section 18 Same as DO-183.	0	Reduces probability of inadvertent activation of remote monitor due to improper equipment design.
7. Induced Audio-Signal Susceptibility	Para 2.3.15 Reference 2.2.6 & DO-160A, Section 19 The ELT Remote Monitor shall operate and meet "Activation Monitor" requirements when its interconnecting wire bundle is subject to induced audio spikes and electric and magnetic fields as specified in Section 19. The ELT shall not activate under these conditions.	Para 2.3.16 Reference 2.2.6 & DO-160C, Section 19 Same as DO-183.	0	Reduces the probability of inadvertent activation of remote monitor due to induced voltages in the wiring.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

C. ELECTROMAGNETIC ENVIRONMENT REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
8. Radio Frequency Energy Emission	Para 2.3.16 Reference DO-160A, Section 21 The equipment shall operate within the RF conducted and radiated permissible levels specified in Section 21.	Para 2.3.18 Reference DO-160C, Section 21 Same as DO-183.	0	Reduces the potential for the ELT to interfere with other avionics systems in the aircraft and in other nearby aircraft.
9. Lightning Induced Transient Susceptibility	Not Addressed	Para 2.3.19 Reference DO-160C, Section 22 The ELT shall not activate as a result of lightning induced transients, and must comply with ELT controls, Self Test, and Aliveness requirements. All mechanical devices shall operate satisfactorily.	+	Increases ability of ELT to withstand the induced effects of lighting.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

D. ENVIRONMENTAL REQUIREMENTS

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
1. Ground Survival (Non-Operating) Temperature	Para 2.3.1.1 & 2.3.1.2 Requires that ELT survive stabilized low temperature of −55° C ±3° and stabilized high temperature of +85° C ±3°.	Para 2.3.1.1 & 2.3.1.2 Requires equipment to soak at high and low temperatures for three hours vice stabilize at those temperatures; otherwise same as DO-183.	+	Soaking units at high and low temperatures is a more stringent test than simply stabilizing the units at the temperature extremes. High temperature limit should reduce the number of internal failures.
2. Operational Temperature	Para 2.3.1.1a, 2.3.1.1b, & 2.3.1.2 Requires that ELT activate and meet operational requirements at −20° ±3° with full PERP, at −40° ± 3° with a reduce PERP of 5 mW (±7 dBm) during a 50 hour period, and at +55° ± 3° with full PERP.	Para 2.3.1.1 & 2.3.1.2 (Activation) Para 2.3.2.1 & 2.3.2.2 (Aliveness) Essentially the same as DO-183, Category C1 must activate and operate at -20 and at +55° C during the 24-hour operational life; extended Category C1 low temperature is −40° C.	0	Lower operating temperature limit in both specifications provides for equipment operation in extreme environments found in Alaska and northern states during winter months. DO-204 does not include C/S T.001 (Nov 88) requirement that operating temperature be permanently marked on beacon.
3. Operational Temperature Variation	Para 2.3.2 Reference DO-160A, Section 5 Requires that ELT must operate at maximum duty cycle during temperature variations of 2 to 5° C minimum per minute between operating temperature extremes of +55° C and −20° C.	Para 2.3.2.3 & 2.3.2.4 Reference Figure 2.7 Requires specific temperature gradient and frequency stability with thermal shock test procedures in lieu of DO-160C, Section 5. ELT must operate during temperature variations of 5° ± 1.0° C per hour between temperature extremes, and after thermal shock of +30° C from lowest operating temperature.	0	Provides improved capability for ELT to operate following rapid temperature changes.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

D. ENVIRONMENTAL REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
4. Thermal Shock Endurance	Not Addressed	Para 2.3.2.4, Table 2-1 Requires a thermal shock from the minimum operating temperature (−40° C or −20° C), depending on category, to 30° C above the minimum operating temperature (i.e., either −10° C or +10° C).	+	
5. Humidity	Para 2.3.3 Reference DO-160A, 6.3.1, Category A Requires that ELT must withstand 48 hours (two cycles) of exposure in a standard humidity environment. A cycle is defined as follows: (a) 8 hours exposure to an atmosphere of 50° C and a relative humidity of at least 95%, and (b) 16 hours exposure to an atmosphere of 38° C or lower an a relative humidity of at least 85%.	Para 2.3.3 Reference DO-160C, 6.3.1, Category A Same as DO-183 with exception of added statement that ELT will not activate as a result of test.	0	

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

D. ENVIRONMENTAL REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
6. High Altitude Survival for Installation in Non-Pressurized Compartments	Para 2.3.1.3 Reference DO-160A, Tables 4-1 & 4-2 Requires ELT equipment to withstand a low temperature of −55° C and a low-pressure equivalent to the maximum operational altitude of the aircraft on which it is installed.	Para 2.3.1.3 Provides specific test requirements in lieu of DO-160C requirements. Requires ELT equipment to withstand a low-pressure, low-temperature environment, and a compression equivalent to a drop from an altitude of 50,000 feet above mean sea level in no more than 2.5 minutes.	+	Adds a compression requirement, making test more realistic of actual conditions.
7. Decompression Survival Requirement	Para 2.3.1.4 Reference DO-160A, 4.6.2 Requires the ELT to withstand an absolute pressure reduction from 8,000 ft MSL (752.6 mbars) to the equivalent of the maximum operational altitude of the aircraft on which it is installed.	Para 2.3.1.4 Provides specific test requirements in lieu of DO-160C requirements. Requires ELT to operate at 10 psia and then withstand an absolute pressure reduction to 1 psia within 25 seconds.	0	
8. Overpressure Survival for Installations in Pressurized Compartments	Para 2.3.1.5 Reference DO-160A, 4.6.3 Requires the ELT to withstand an absolute pressure of 1697.3 mbars (15,000 feet below mean sea level).	Para 2.3.1.5 Same as DO-183.	0	

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SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
9. Vibration Endurance	Para 2.3.5 In lieu of DO-160A, requires that the ELT will not activate during exposure to a vibratory motion (varying at a rate not to exceed 1.0 octave/minute) in all three major orthogonal ELT axes.	Para 2.3.5 Reference DO-160C, Section 8 Same as DO-183.	0	
10. Waterproofness	Para 2.3.7.2 (Spray Proof) Para 2.3.7.1 (Drip Proof when required) Reference DO-160A, 10.3.1 & 10.3.2 Requires that ELT in operating mode shall withstand 15 minutes of spray water on all six sides and, if required, falling drip water as specified in 10.3.1 and 10.3.2. Compliance is tested after the 15 minute water spray.	Para 2.3.8.1 (Drip Proof when required) Para 2.3.8.2 (Spray Proof) Reference DO-160C, 10.3.1 & 10.3.2 Same as DO-183.	0	Both specifications provide for improved capability to withstand water penetration.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
11. Salt Water Resistance (Corrosion)	Para 2.3.11 (Salt Water Spray – Optional for AF) Reference DO-160A, Section 14, Category S Requires that ELT must withstand a salt fog atmosphere at 35° C for a 48-hour period and 48-hour drying period at ambient temperatures.	Para 2.3.12 (Salt Water Spray – Optional for AF) Reference DO-160C, Section 14, Category S Same as DO-183.	0	Both specifications provide for improved capability of ELT to operate in a salt water environment.
	Para 2.3.8.2 (Salt Water Immersion – Optional for AF) Reference DO-160A, Para 11.2.2, 14.3.4, & 14.3.4.1 Requires that ELT must withstand a 24-hour salt water immersion at 30° C to 40° C and a 160-hour drying period at 65° C.	Para 2.3.9.2 (Salt Water Immersion – Optional for AF) Para 2.3.9.4 (Post Crash Immersion) Reference DO-160C, Para 11.4.2, 14.3.4, & 14.3.4.1 Salt water immersion test is same as DO-183. Post crash immersion is added requiring ELT to be activated and then survive a 1-hour immersion, submerged greater than 3 feet in salt solution 30° C to 40° C.	+	Post crash test specification provides for improved capability of ELT to operate in a salt water environment.
12. Fluids Susceptibility	Para 2.3.8.1 (Fluid Spray when required) Reference DO-160A, 11.4.1 Requires that ELT must withstand a 24-hour fine mist wetted condition and 160-hour drying period at 65° C.	Para 2.3.9.1 (Fluid Spray when required) Reference DO-160C, 11.4.1 Requires that ELT must withstand a 24-hour immersion period and 160-hour drying period at 65° C.	0	Both specifications provide improved performance of ELT installations in areas where fluid contamination could be encountered.

[1] Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

D. ENVIRONMENTAL REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
12. Fluids Susceptibility (cont.)	Para 2.3.8.3 (Fluid Immersion when required) Reference DO-160A, 11.4.2 Requires ELT to withstand a 24-hour immersion period and a 160-hour drying period at 65° C.	Para 2.3.9.3 (Fluid Immersion when required) Reference DO-160C, 11.4.2 Same as DO-183.	0	
13. Blowing Sand and Dust Resistance	Para 2.3.9 Reference DO-160A, Section 12 When required, ELT must withstand a dust and sand jet between 0.5 and 2.5 m/sec during a 1-hour period at 25° C and 30% relative humidity along each major orthogonal axis.	Para 2.3.10 Reference DO-160C, Section 12 Same as DO-183.	0	Both specifications provide improved reliability of ELT under environmental conditions where blowing sand and dust are prevalent.
14. Fungus Resistance	Para 2.3.10 Reference DO-160A, Section 13 When required, ELT must withstand a 28-day fungus growth period at 305° C and 97% relative humidity followed by a 48-hour drying period at room temperature.	Para 2.3.11 Reference DO-160C, Section 13 Same as DO-183.	0	

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

D. ENVIRONMENTAL REQUIREMENTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
15. Explosion Proofness	Para 2.3.6 Reference DO-160A, Section 9 Requires that when activated in a test chamber the ELT will not cause detonation of the chamber explosive mixture (when required).	Para 2.3.6 Reference DO-160C, Section 9 Same as DO-183.	0	Both specifications provide improved reliability of ELT regarding potential to cause in-flight or post-crash explosions.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

E. INSTALLED EQUIPMENT PERFORMANCE & OPERATIONAL TESTS

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
1. Equipment Installation	Para 3.1 Provides specific requirements for ELT installation in aircraft which takes in to account accessibility, aircraft environment, display visibility, dynamic response, failure protection, inadvertent turn-off, ELT location, crash sensor orientation, antenna installation and location, and coaxial cable installation and integrity.	Para 3.3 Same as DO-183 with the exception of antenna polarity which may be either circular or vertical.	0	Both specifications provide major improvement in survivability and performance of aircraft mounted ELTs.
2. Installed Equipment	Para 3.2 Supplements paragraph 2.1 and 2.2 by adding installed equipment requirements of dynamic response and interference effects.	Para 3.2 Same as DO-183	0	
3. Condition of Test	Para 3.3 Requires testing with other avionics equipment operating.	Para 3.3 Same as DO-183	0	Both specifications provide for improved compatibility of ELT equipment with aircraft equipment.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

E. INSTALLED EQUIPMENT PERFORMANCE & OPERATIONAL TESTS(cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
4. Test Procedures for Installed Equipment Performance	Para 3.4 Requires visual and operational inspection of installed equipment to meet requirements of Section 2 with specific requirements to test Remote Monitor (audio and/or visual) and Remote Control, accessibility and interference effects.	Para 3.4 Requires visual and operational inspection of installed equipment with specific requirements to test Remote Monitor (audio and visual) and Remote Control, and equipment accessibility. Does not require tests for interference effects.	+	Both specifications add specific requirement to test both the visual and the remote monitors which will provide greater reliability of installed equipment.
5. Operational Tests	Para 4.0 Provides pre-flight and post-flight procedures, operational checks and inspection requirements.	Para 4.0 Amplifies on the procedures contained in DO-183, and requires use of self test function during preflight and activation monitors during post-flight.	+	Improves overall reliability by providing enhanced confidence checks of ELT on a regular basis.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

E, INSTALLED EQUIPMENT PERFORMANCE & OPERATIONAL TESTS (cont.)

SPECIFICATION REQUIREMENT	RTCA/DO-183 (MAY 1983)	RTCA/DO-204 (SEP 1989)	I. F.[1]	COMMENTS
6. Power Supply	Para 2.1.11 Specifies that battery shelf life shall not be greater than one-half the cell manufacturer's stated shelf life and that the expiration date be clearly marked on an external label. Provides for use of aircraft battery or other supplemental power supply for Remote Monitor/Control and/or charging.	Para 2.1.12 Reference DO-188 Requires the ELT to have its own integral battery and not depend upon any external source of power for its operation once activated. Requires provisions to ensure the watertight integrity of ELT following battery replacement. Requires that ELT not be hazardous to personnel when ELT is handled, operated, or serviced; and that ELT will not release toxic or corrosive products outside case during or subsequent to storage at temperatures between −55° C and +85° C. Defines useful life as the period after manufacture that the battery will continue to meet input power requirements subsequent to storage at +20° C. Requires that batteries be protected against polarity reversal, shorting, and the effects of self-heating, cell-to-cell charging and forced discharging.	+	Extends on requirements of DO-183 with regard to: battery useful life, shelf life, and internal battery protection. Provides for increased personal safety when handling battery. Ensures ELT water-tight integrity following battery replacement.

[1]Improvement Factor: 0 = No Improvement; + = Improvement; S+ = System Improvement; N/A = Can't be Compared

APPENDIX B

DERIVATION OF LIVES SAVED WITH 406 MHz ELTs (TSO-C126)

APPENDIX B

DERIVATION OF LIVES SAVED WITH 406 MHz ELTs (TSO-C126)

I. BACKGROUND:

The NASA Study[1] examined the survival rate of accidents where a search was required based on a six year period using information derived from NTSB accident folders containing Supplement M data (aircraft accidents where a search was required). The total number of accidents in the six year data set was 662, (see Table 14, Attachment 1); however, AFRCC records indicate that an average of 192 searches for aircraft crashes are conducted each year for missing aircraft (where no ELT was transmitting) and approximately 30 ELT search missions involving actual crashes, for a total of 222 searches a year. The NASA study (p. 28) noted that the number of NTSB accident records was significantly lower than the actual number of searches. Consequently, an adjustment was made to the number of lives actually lost each year by looking at the total NTSB data base during the same period of time (p. 27 of Ref.). This adjustment appears to be justified on the basis that the 662 cases is approximately 1/2 the number of actual searches conducted for the period.

Discussions with NTSB crash investigators, have verified that the recorded Supplement M data is an optional form subject to the discretion of the crash investigator whose focus is more on the causes of the crash rather than the aftermath. This explains the inconsistency in the number of search cases reported by NTSB vs. the number of actual searches conducted. As a result, we assume a total of 222 searches each year and multiply the NTSB data (number of persons involved) in Table 14 (Attachment 1) by a factor of 2. This adjustment is reflected in Tables B-2 and B-3. (Attachments 2 and 3)

A survivability curve was drawn (Attachment 4) based upon data from the NTSB data base and consistent with the slope of the data in the Mundo report[2] and the Coast Guard SALTTI Study[3]. The Mundo curve was also supported in a statement by DeHart and Beers: [4] "Within the first 8 hours the survival rate is more than 50%. Should the rescue be delayed beyond 2 days, however, the survival rate drops to less than 10%." The approach and survival curve was reviewed by persons from the NTSB; the National SAR School; the Aircraft Accident Research Center; Civil Aeronautical Medical Institute; FAA, Oklahoma City; and the US Army Aeromedical Research Lab,

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[1] "Current Emergency Transmitter (ELT) Deficiencies and Potential Improvements Utilizing TSO-C91a ELTs", NASA Contractor Report 4330 dated October 1990.
[2] DoD & NSC data given in C. Mundo, L. Tami & G. Larson, Final Report Program Plan for Search & Rescue Electronics Alerting and Locating System, DOT-TSC-OST-73-42, February 1974.
[3] Study of Alerting and Locating Techniques and Their Impact (SALTTI), prepared for U.S. Coast Guard by Computer Sciences Corp, 18 September 1975
[4]. DeHart RL, Ed. Fundamentals of Aerospace Medicine, Philadelphia: Lea & Febinger, 1985: 862-67.

Ft. Rucker, Alabama. All reviewers found the curve to be a reasonable estimating tool to predict survivability of persons involved in an aircraft crash.

The representative from Ft. Rucker was concerned that the accidents in the NTSB data set, where the ELT did not operate, might reflect the severity of those accidents. Therefore, the survivability of the ELT, as well as the people involved in those accidents, could be questioned. As a result of this comment, the data from accidents (with Supplement M data) was reviewed. This review revealed that 31% of the non-ELT accidents had survivors while 43% of the ELT-aided accidents had survivors. **This 12% difference was used to adjust the number of expected survivors** from the data set where no ELT was involved.

II. APPROACH TO DERIVING LIVES SAVED

The expected saving of 25 lives per year (from the NASA study) due to the carriage of the improved 121.5 MHz ELTs has already taken into account the limited data set in the NTSB data base because of lack of Supplement M data in approximately half of the search cases. (See page 28 and 29 of NASA Report). Making this 12% adjustment **reduces the improved 121.5 MHz ELT benefit to 22 lives per year.**[5]

The expected saving of lives due to the carriage of 406 MHz ELTs is calculated below based on the data developed in Table B-1 and B-2 which projects the total number of accidents and people involved by using a factor of 2 times the NTSB data. This represents the ratio between the number of actual searches conducted over a six year period (1,332) over the number of accidents from Supplement M reported accidents (662).

Table B-1 examines the lives lost each year based on the failure of the old 121.5 (C91) ELTs. Table B-2 examines the lives lost each year due to improved human survivability in cases where the ELT worked in the past. Both the Low Earth Orbit case and the GEOSAR Orbit case are examined.

<u>The logic flow for calculation of lives saved is depicted in the flow diagram of Attachment 5.</u>

III. DERIVATION OF LIVES SAVED USING 406 MHZ ELTS WITH THE LEO SYSTEM.

1. NINETY-SIX LIVES ARE LOST EACH YEAR AS A RESULT OF THE CURRENT FAILURE RATE OF 75% (SEE TABLE B-1) BASED UPON THE IMPROVED 406 MHz SAR TIMELINE.

[5] The NASA study indicated a possible savings of 25 lives per year with the use of TSO c-91a, 121.5 MHz ELTs.

2. BY REDUCING THE FAILURE RATE TO 19% THE NUMBER OF LIVES LOST GOES TO 24 PER YEAR. FOLLOWING IS THE CALCULATION:

$$\frac{75\%}{96} = \frac{19\%}{X}$$

X = 24 LIVES LOST/YEAR

3. TO GET THE NUMBER OF LIVES **SAVED** EACH YEAR YOU SUBTRACT 24 FROM 96 RESULTING IN 72 LIVES SAVED EACH YEAR. THE 12% ADJUSTMENT (DUE TO THE SEVERITY OF SOME ACCIDENTS) REDUCES THIS TO **63 LIVES** PER YEAR.

IN SUMMARY IT IS ESTIMATED THAT
63 LIVES PER YEAR (1)
WOULD BE SAVED DUE TO THE IMPROVED ELT EQUIPMENT
AND THE REDUCED 406 MHZ SAR TIMELINE
WITH THE LEO SYSTEM

IV. DERIVATION OF LIVES SAVED WITH 406 MHZ ELTS WITH GEOSAR SYSTEM.

1. ONE HUNDRED THIRTY-NINE LIVES ARE LOST EACH YEAR AS A RESULT OF THE CURRENT FAILURE RATE OF 75% (SEE TABLE B-1 FOR GEOSAR SYSTEM.) BASED UPON THE IMPROVED 406 MHZ TIMELINE.

2. BY REDUCING THE FAILURE RATE TO 19% THE NUMBER OF LIVES LOST REDUCES TO 35 PER YEAR. FOLLOWING IS THE CALCULATION:

$$\frac{75\%}{139} = \frac{19\%}{X}$$

X = 35 LIVES LOST/YEAR

3. TO DETERMINE THE NUMBER OF LIVES **SAVED** EACH YEAR SUBTRACT 35 FROM 139 AND GET 104 LIVES SAVED EACH YEAR. APPLICATION OF THE 12% FACTOR REDUCES THIS TO 92 LIVES PER YEAR. (AN INCREASE OF 29 LIVES DUE TO GEOSAR). TO CONTINUE THE CONSERVATIVE APPROACH REDUCE THE NUMBER OF LIVES DUE TO THE GEOSAR SYSTEM (29) BY THE EFFECTIVENESS OF THE GEOSAR SYSTEM TO 80% (DUE TO REGISTRY ERRORS AND OTHER FACTORS) WHICH RESULTS IN 86 LIVES PER YEAR.

IN SUMMARY IT IS ESTIMATED THAT
86 LIVES PER YEAR (2)
WOULD BE SAVED DUE TO THE IMPROVED ELT EQUIPMENT AND THE 406 MHZ SAR TIMELINE WITH THE GEOSAR SYSTEM ADDED

V. DERIVATION OF LIVES SAVED DUE TO IMPROVED HUMAN SURVIVABILITY FROM 406 MHZ ELT USE WITH LEO SYSTEM.

1. FROM TABLE B-2, 1,296 PEOPLE WERE INVOLVED IN ACCIDENTS WHERE THE ELT WORKED. THE RESULTANT SURVIVABILITY RATE WITH 121.5 MHZ ELTS WAS 34%.

2. FROM THE SURVIVABILITY RATE IMPROVEMENT TO 50% DUE TO 406 MHZ ELTS USED WITH THE LEO SYSTEM, AN ADVANTAGE OF 16% IS ACHIEVED. THIS RESULTS IN A POTENTIAL OF **35 LIVES** SAVED PER YEAR. THE CALCULATION FOLLOWS:

SURVIVABILITY ADVANTAGE WHEN 406 MHZ ELTS ARE USED WITH THE LEO SYSTEM IN CASES WHERE ELT WORKED IN THE PAST[6]:

16% X 1296 PEOPLE INVOLVED =
207 LIVES OVER 6 YEARS
OR 35 LIVES PER YEAR (3)

VI. DERIVATION OF LIVES SAVED DUE TO IMPROVED SURVIVABILITY FROM 406 MHZ ELT USE WITH GEOSAR SYSTEM.

1. FROM TABLE B-2, 1,296 PEOPLE WERE INVOLVED IN ACCIDENTS WHERE THE 121.5 MHZ ELT WORKED. THE RESULTANT SURVIVABILITY RATE WAS 34%.

2. FROM THE SURVIVABILITY RATE IMPROVEMENT TO 64% DUE TO 406 MHZ ELT USE WITH THE GEOSAR SYSTEM, AN ADVANTAGE OF 30% IS ACHIEVED. THIS RESULTS IN A POTENTIAL **OF 65 LIVES** SAVED PER YEAR. THE CALCULATION FOLLOWS:

[6] In cases where the ELT worked in the past (par. v & vi) the 12% reduction factor is not applicable.

SURVIVABILITY ADVANTAGE WHEN 406 MHZ ELTS ARE USED WITH THE GEOSAR SYSTEM IN ACCIDENTS WHERE THE ELT HAS WORKED IN THE PAST:

30% X 1296 PEOPLE INVOLVED =

389 LIVES OVER 6 YEARS

OR 65 LIVES PER YEAR

APPLY A REDUCTION TO THE ADDED LIVES SAVED FROM THE GEOSAR SYSTEM (30) TO ACCOUNT FOR THE EFFECTIVENESS OF THE GEOSAR SYSTEM TO 80% THE RESULT IS

59 LIVES PER YEAR (4)

VII. SUMMARY OF CALCULATIONS OF ADDITIONAL LIVES SAVED USING 406 MHZ ELTS

FROM LEO SYSTEM ALONE

98 LIVES PER YEAR [7]

WITH ADDED BENEFIT FROM GEOSAR SYSTEM

A TOTAL OF 145 LIVES PER YEAR [8]

VIII. ADJUSTMENT OF TOTAL LIVES TO BE SAVED BASED UPON EXPERIENCE THAT THE WEATHER FACTOR IN 10% OF SEARCHES WOULD PREVENT RESCUE.

A total of 556 NTSB records were studied to examine the effects of the weather on the potential for saving lives when the ELT worked and the timeline was reduced. The assumption was made that despite the efficiency of the ELT, there are cases where weather prevents rescue efforts. The percentage of cases where weather hampered the rescue was estimated to be 10%. This was determined by the number of rescues less than 12 hours (15%) and the number less than 24 hours (9%). This factor was then applied to the total lives to be saved.

TOTAL OF 131 LIVES PER YEAR

TO BE SAVED USING 406 MHZ ELTS

AND

20 LIVES PER YEAR USING IMPROVED 121.5 MHZ ELTS

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[7] From the addition of (1) and (3) results.

[8] From the addition of (2) and (4) results.

IX. **ADDITION OF THREE LIVES LOST EACH YEAR DUE TO CAP LOSES IN SEARCHES WHERE AN ELT IS NOT TRANSMITTING BRINGS TOTAL LIVES TO BE SAVED EACH YEAR TO:**

FINAL TOTAL OF LIVES TO SAVED BY 406 MHZ ELTS

134 LIVES PER YEAR

FINAL TOTAL OF LIVES TO BE SAVED
BY TSO-C91a 121.5 MHz ELTs

23 LIVES PER YEAR

<u>ATTACHMENTS</u>

Table 14*
NTSB Survivor Data Where a Search Was Required
(1 January 1983 through 17 October 1988)

	# of Accidents	# People Involved	# of Survivors	Survival Rate
A. Accidents where ELT was operating	255	648	222	34%
B. Accidents where ELT was not operating	407	928	179	19%

Survivability Advantage When ELT is Operating
34%-19%=
15%

Lives lost from 1983 through 17 October 1988 due to ELT not operating
15% x 928 people involved =
139 LIVES

Number of lives lost per year due to ELT failure
139 / 6 years =
23 LIVES / YEAR

***From NASA Report**

ATTACHMENT 1

TABLE B-1*
Lives Lost due to ELT Failures Using 406 MHz ELT Improvements and 406 MHz SAR Timeline

	# of Accidents	# People Involved	# of Survivors	Survival Rate **
A. Accidents where ELT was operating	510	1296	444	34%
B. Accidents where ELT was not operating	814	1856	358	19%

Survivability Advantage When 406 MHz ELT is Operating
With COSPAS-SARSAT LEO System
50 % -19 %=
31 %

Lives lost from 1983 through 17 October 1988 due to ELT not operating
31 % x 1856 people involved =
575 LIVES

Number of lives lost per year due to ELT failure
575 / 6 years =
96 LIVES / YEAR

Survivability Advantage When 406 MHz ELT is Operating
With Geostationary System
64 % -19 %=
45 %
Lives lost from 1983 through 17 October 1988 due to ELT not operating
45 % x 1856 people involved =
835 LIVES

Number of lives lost per year due to ELT failure
835/ 6 years =
139 LIVES / YEAR

*Modified to estimate data for total number of accidents

**Same survival rate as NTSB Data Set is assumed

ATTACHMENT 2

TABLE B-2*
Lives Lost based on Reduced SAR Timeline
Using 406 MHz in Accidents
Where the ELT Worked in the Past

	# of Accidents	**# People Involved**	**# of Survivors**	**Survival Rate ****
A. Accidents where ELT was operating	510	1296	444	34%
B. Accidents where ELT was not operating	814	1856	358	19%

Survivability Advantage From 406 MHz when
121.5 MHz ELT Operated in Past
With COSPAS-SARSAT LEO System
50 %-34% =
16 %
Lives lost from 1983 through 17 October 1988 due to Delays in Rescue
16 % x 1296 people involved =
207 LIVES
Number of lives lost per year due to Rescue Delays
with 121.5 MHz ELTs
207/ 6 years =
35 LIVES / YEAR

Survivability Advantage From 406 MHz ELT Where 121.5 MHz ELT
Operated in Past
With Geostationary System
64 %-34%=
30 %
Lives lost from 1983 through 17 October 1988 due to Delays in Rescue
30 % x 1296 people involved =
389 LIVES

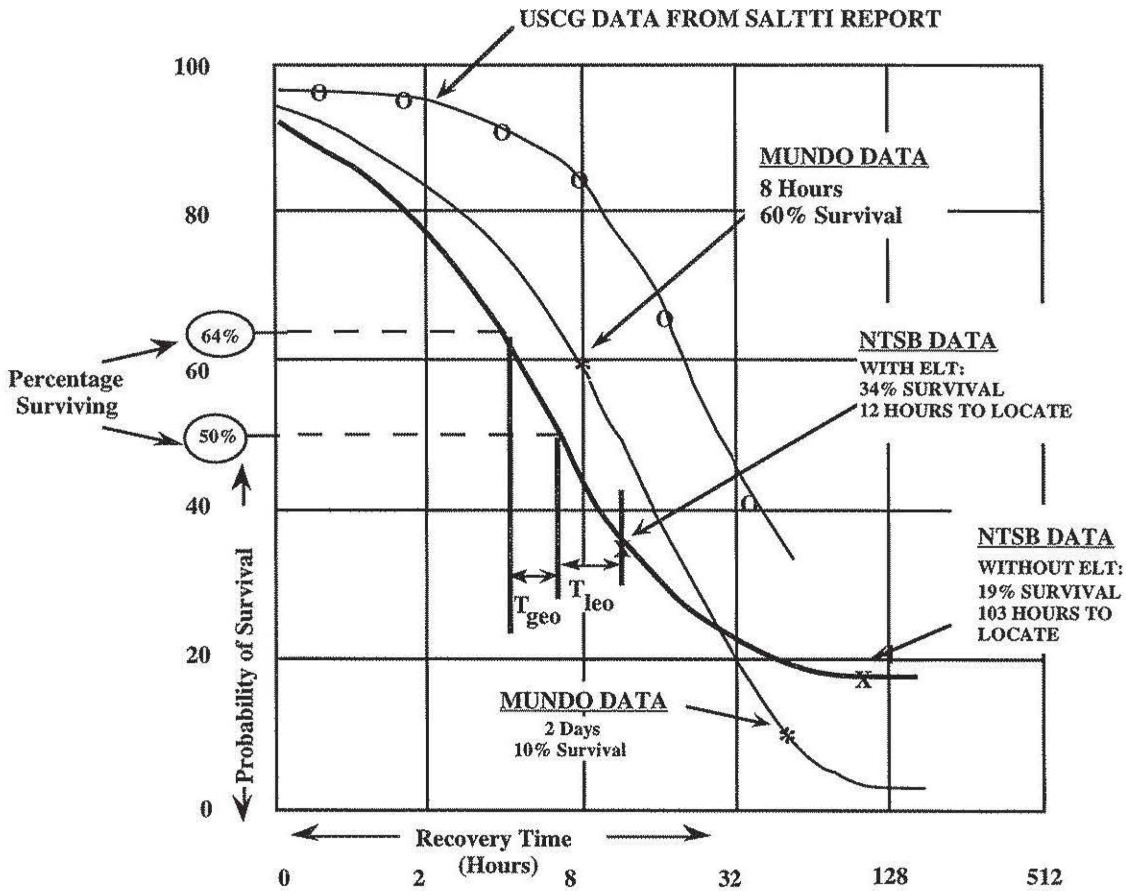
Number of lives lost per year due to Delays in Rescue
389/ 6 years =
65 LIVES / YEAR

* Modified to estimate data for total number of accidents

** Same survival rate as NTSB Data Set is assumed for121.5 MHz ELTs

ATTACHMENT 3

Survivability in Aircraft Crashes Projected from Use of 406 MHz ELTs Based on NTSB Data



LEGEND

T_{leo} = Timeline saving due to use of 406 MHz ELTs = 6.7 hrs using COSPAS-SARSAT LEO system

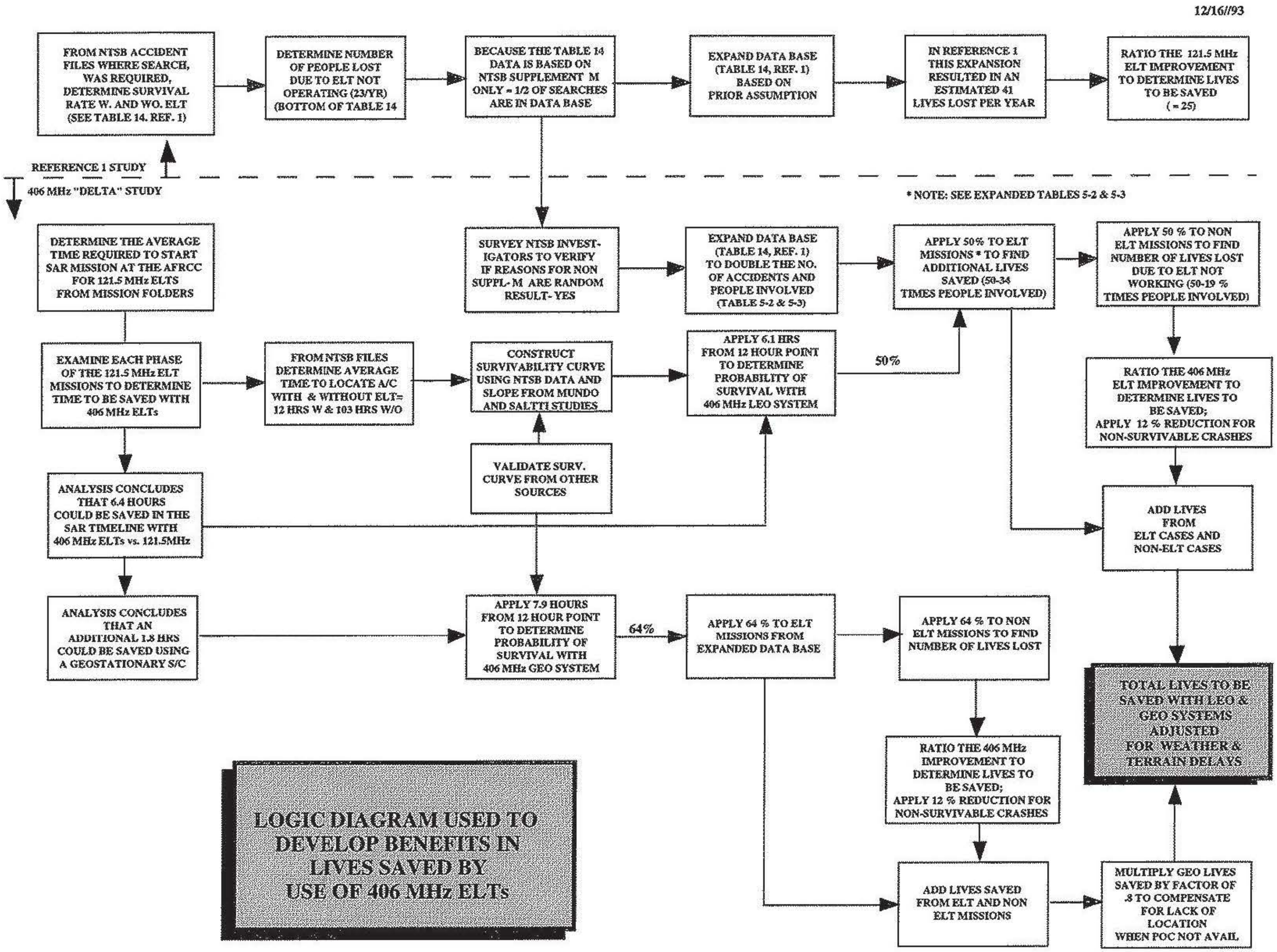
T_{geo} = Timeline saving due to use of 406 MHz ELTs = 1.6 hrs using 406 MHz GEO system

REFERENCES:

DOD & NSC data given in C. Mundo, L. Tami & G. Larson, Final Report Program Plan for Search & Rescue Electronics Alerting and Locating System, DOT-TSC-OST-73-42, February 1974.

U.S. Coast Guard Cost Benefit Analysis, Study of Alerting Locating Techniques and Their Impact (SALTTI), 18 September 1975, pg. 4-29, Table 4-11.

ATTACHMENT 4


12/16//93
FROM NTSB ACCIDENT FILES WHERE SEARCH, WAS REQUIRED, DETERMINE SURVIVAL RATE W. AND WO. ELT (SEE TABLE 14. REF. 1)
DETERMINE NUMBER OF PEOPLE LOST DUE TO ELT NOT OPERATING (23/YR) (BOTTOM OF TABLE 14
BECAUSE THE TABLE 14 DATA IS BASED ON NTSB SUPPLEMENT M ONLY = 1/2 OF SEARCHES ARE IN DATA BASE
EXPAND DATA BASE (TABLE 14, REF. 1) BASED ON PRIOR ASSUMPTION
IN REFERENCE 1 THIS EXPANSION RESULTED IN AN ESTIMATED 41 LIVES LOST PER YEAR
RATIO THE 121.5 MHz ELT IMPROVEMENT TO DETERMINE LIVES TO BE SAVED (= 25)
REFERENCE 1 STUDY
406 MHz "DELTA" STUDY
* NOTE: SEE EXPANDED TABLES 5-2 & 5-3
DETERMINE THE AVERAGE TIME REQUIRED TO START SAR MISSION AT THE AFRCC FOR 121.5 MHz ELTS FROM MISSION FOLDERS
SURVEY NTSB INVEST-IGATORS TO VERIFY IF REASONS FOR NON SUPPL- M ARE RANDOM RESULT- YES
EXPAND DATA BASE (TABLE 14, REF. 1) TO DOUBLE THE NO. OF ACCIDENTS AND PEOPLE INVOLVED (TABLE 5-2 & 5-3)
APPLY 50% TO ELT MISSIONS * TO FIND ADDITIONAL LIVES SAVED (50-34 TIMES PEOPLE INVOLVED)
APPLY 50 % TO NON ELT MISSIONS TO FIND NUMBER OF LIVES LOST DUE TO ELT NOT WORKING (50-19 % TIMES PEOPLE INVOLVED)
EXAMINE EACH PHASE OF THE 121.5 MHz ELT MISSIONS TO DETERMINE TIME TO BE SAVED WITH 406 MHz ELTs
FROM NTSB FILES DETERMINE AVERAGE TIME TO LOCATE A/C WITH & WITHOUT ELT= 12 HRS W & 103 HRS W/O
CONSTRUCT SURVIVABILITY CURVE USING NTSB DATA AND SLOPE FROM MUNDO AND SALTTI STUDIES
APPLY 6.1 HRS FROM 12 HOUR POINT TO DETERMINE PROBABILITY OF SURVIVAL WITH 406 MHz LEO SYSTEM
50%
RATIO THE 406 MHz ELT IMPROVEMENT TO DETERMINE LIVES TO BE SAVED; APPLY 12 % REDUCTION FOR NON-SURVIVABLE CRASHES
ANALYSIS CONCLUDES THAT 6.4 HOURS COULD BE SAVED IN THE SAR TIMELINE WITH 406 MHz ELTs vs. 121.5MHz
VALIDATE SURV. CURVE FROM OTHER SOURCES
ADD LIVES FROM ELT CASES AND NON-ELT CASES
ANALYSIS CONCLUDES THAT AN ADDITIONAL 1.8 HRS COULD BE SAVED USING A GEOSTATIONARY S/C
APPLY 7.9 HOURS FROM 12 HOUR POINT TO DETERMINE PROBABILITY OF SURVIVAL WITH 406 MHz GEO SYSTEM
64%
APPLY 64 % TO ELT MISSIONS FROM EXPANDED DATA BASE
APPLY 64 % TO NON ELT MISSIONS TO FIND NUMBER OF LIVES LOST
TOTAL LIVES TO BE SAVED WITH LEO & GEO SYSTEMS ADJUSTED FOR WEATHER & TERRAIN DELAYS
RATIO THE 406 MHz IMPROVEMENT TO DETERMINE LIVES TO BE SAVED; APPLY 12 % REDUCTION FOR NON-SURVIVABLE CRASHES
ADD LIVES SAVED FROM ELT AND NON ELT MISSIONS
MULTIPLY GEO LIVES SAVED BY FACTOR OF .8 TO COMPENSATE FOR LACK OF LOCATION WHEN POC NOT AVAIL
LOGIC DIAGRAM USED TO DEVELOP BENEFITS IN LIVES SAVED BY USE OF 406 MHz ELTs